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RICHARD W. WIEKING
CLERK
U.S. DISTRICT COURT
NO. DIST. OF CA S.J.

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN JOSE DIVISION

ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Plaintiffs, vs. RICOH COMPANY, LTD., Defendant.	Case No. C 07 01942 PVT **COMPLAINT FOR DECLARATORY JUDGMENT** **JURY TRIAL DEMANDED**

Plaintiffs ASUSTeK Computer Inc. and ASUS Computer International (collectively, "ASUSTEK"), by their undersigned attorneys, file this Complaint against Ricoh Company, Ltd. ("RICOH"):

INTRODUCTION

1. This action concerns the invalidity and non-infringement of the following four United States Patents, which, on information and belief, are owned by RICOH by assignment: U.S. Patent No. 5,063,552; U.S. Patent No. 6,172,955; U.S. Patent No. 6,631,109; and U.S. Patent No. 6,661,755 (collectively, the "PATENTS-IN-SUIT").

2. RICOH filed a Complaint for Patent Infringement in the Western District of Wisconsin titled *Ricoh Company Ltd. v. Asustek Computer Inc. et al.*, Civil Action No. 06-C-0462-C (the "WISCONSIN ACTION"). In the WISCONSIN ACTION, RICOH alleged that ASUSTEK manufactures, markets, sells, and offers for sale products that infringe certain claims of the PATENTS-IN-SUIT. On April 3, 2007, the WISCONSIN ACTION was dismissed as to ASUSTEK for lack of personal jurisdiction without prejudice. The WISCONSIN ACTION is still pending against other defendants, including Quanta Computer Inc., Quanta Storage Inc., Quanta Computer, USA, Inc., New Universe Technology, Inc., and Nu Technology, Inc.

3. In light of RICOH's prior litigation against ASUSTEK asserting certain claims of the PATENTS-IN-SUIT (and related patents), and now that the WISCONSIN ACTION has been dismissed against ASUSTEK for lack of personal jurisdiction, ASUSTEK has an objective, reasonable apprehension that RICOH will attempt to file a new action for patent infringement against ASUSTEK in another jurisdiction.

4. Accordingly, ASUSTEK respectfully requests a declaration from this Court that ASUSTEK does not infringe any claim of the PATENTS-IN-SUIT by making, selling, importing, or offering to sell its products and to further declare the asserted claims of the PATENTS-IN-SUIT invalid.

THE PARTIES

5. ASUSTeK Computer Inc. ("ASUSTeK") is a Taiwanese company with its principal place of business in Taiwan, Republic of China.

6. ASUS Computer International ("ACI") is a California company, located in Fremont, California. ACI is a wholly owned subsidiary of ASUSTeK.

7. ASUSTEK is informed and believes that RICOH is a Japanese Corporation with its principal place of business in Tokyo, Japan. ASUSTEK is informed and believes that RICOH is the owner of record of the PATENTS-IN-SUIT by assignment.

JURISDICTION

8. This Court has jurisdiction over all claims for declaratory judgment of patent non-infringement and invalidity set forth herein under 28 U.S.C. §§ 1331 and 1338(a), the Declaratory Judgment Act, 28 U.S.C. §§ 2201 and 2202, and under the laws of the United States concerning patents, 35 U.S.C. §§ 1 *et seq.*

9. Jurisdiction over RICOH is proper in this Court because RICOH has continuous, systematic, and substantial contacts with the State of California. On information and belief, RICOH sells, offers to sell, imports, repairs, and services products in California, including the Northern District of California. Upon further information and belief, RICOH has participated as a party in the past, and is currently a party in other actions that are now pending, in the Northern District of California.

VENUE

10. Venue is proper in the Northern District of California under 28 U.S.C. §§ 1391(b), 1391(c), and 1391(d).

FACTUAL BACKGROUND

The Patents-In-Suit

11. The PATENTS-IN-SUIT describe technologies relating to optical storage devices.

12. U.S. Patent No. 5,063,552 (the '552 Patent) entitled "Optical disk apparatus with data transfer rate and rotational speed variable by annular zones" issued on November 5, 1991 and lists Toshihiro Shigemori as inventor. On information and belief, RICOH asserts that it is the owner by assignment of the '552 Patent. A true and correct copy of the '552 Patent is attached hereto as Exhibit A.

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13. U.S. Patent No. 6,172,955 (the '955 Patent) entitled "Optical disc recording and reproducing apparatus for performing a formatting process as a background process and a method for formatting an optical disc by a background process" issued on January 9, 2001 and lists Hirokuni Hashimoto as inventor. On information and belief, RICOH asserts that it is the owner by assignment of the '955 Patent. A true and correct copy of the '955 Patent is attached as Exhibit B.

14. U.S. Patent No. 6,631,109 (the '109 Patent) entitled "Optical recording method and apparatus, and optical storage medium" issued on October 7, 2003 and lists Yuki Nakamura as inventor. On information and belief, RICOH asserts that it is the owner by assignment of the '109 Patent. A copy of the '109 Patent is attached as Exhibit C.

15. U.S. Patent No. 6,661,755 (the '755 Patent) entitled "Optical disc apparatus" issued on December 9, 2003 and lists Kazutaka Yamamoto as inventor. On information and belief, RICOH asserts that it is the owner by assignment of the '755 Patent. A true and correct copy of the '755 Patent is attached as Exhibit D.

Controversy Between ASUSTEK and RICOH

16. On August 24, 2006, RICOH filed the WISCONSIN ACTION. Therein, RICOH alleged that ASUSTEK "participated in a stream of commerce" between Taiwan, China and the United States, including Wisconsin, whereby ASUSTEK used "purposefully selected" intermediaries and distribution channels to manufacture or cause to be manufactured and shipped into the United States, including Wisconsin, optical storage devices that allegedly infringe certain claims of the PATENTS-IN-SUIT.

17. On December 29, 2006, RICOH amended its Complaint to reflect a change in the parties to the action. A true and correct copy of RICOH's Amended Complaint is attached hereto as Exhibit E.

18. On January 18, 2007, ASUSTEK filed a Motion to Dismiss the WISCONSIN ACTION for lack of personal jurisdiction over ASUSTEK on the grounds that the Wisconsin Long Arm Statute was inapplicable as against ASUSTEK and the exercise of personal jurisdiction over ASUSTEK would violate due process.

19. On April 3, 2007, the United States District Court for the Western District of Wisconsin, J. Crabb presiding, issued an Opinion and Order dismissing the WISCONSIN ACTION against ASUSTEK. A true and correct copy of the Order is attached hereto as Exhibit F.

COUNT 1

Declaratory Judgment

(Invalidity of U.S. Patent No. 5,063,552)

20. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

21. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing the '552 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1 and 8 of the '552 Patent.

22. Each of the asserted claims of the '552 Patent is invalid for failing to satisfy one or more of the conditions of patentability set forth in Title 35 of the United States Code.

23. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the validity of the asserted claims of the '552 Patent within the meaning of 28 U.S.C. § 2201.

24. Therefore, a judicial declaration of invalidity of the '552 Patent is necessary and appropriate in order to resolve this controversy.

COUNT II

Declaratory Judgment

(Non-Infringement of U.S. Patent No. 5,063,552)

25. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

26. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing certain claims of the '552 Patent have created in ASUSTEK an

objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1 and 8 of the ‘552 Patent.

27. None of ASUSTEK’s products infringe the asserted claims of the ‘552 Patent.

28. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the infringement of the asserted claims of the ‘552 Patent within the meaning of 28 U.S.C. § 2201.

29. Therefore, a judicial declaration of non-infringement of the ‘552 Patent is necessary and appropriate in order to resolve this controversy.

COUNT III

Declaratory Judgment

(Invalidity of U.S. Patent No. 6,172,955)

30. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

31. RICOH’s actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing the ‘955 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 8-14 of the ‘955 Patent.

32. Each of the asserted claims of the ‘955 Patent is invalid for failing to satisfy one or more of the conditions of patentability set forth in Title 35 of the United States Code.

33. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the validity of the asserted claims of the ‘955 Patent within the meaning of 28 U.S.C. § 2201.

34. Therefore, a judicial declaration of invalidity of the ‘955 Patent is necessary and appropriate in order to resolve this controversy.

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COUNT IV

Declaratory Judgment

(Non-Infringement of U.S. Patent No. 6,172,955)

35. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

36. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing certain claims of the '955 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 8-14 of the '955 Patent.

37. None of ASUSTEK's products infringe the asserted claims of the '955 Patent.

38. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the infringement of the '955 Patent within the meaning of 28 U.S.C. § 2201.

39. Therefore, a judicial declaration of non-infringement of the asserted claims of the '955 Patent is necessary and appropriate in order to resolve this controversy.

COUNT V

Declaratory Judgment

(Invalidity of U.S. Patent No. 6,631,109)

40. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

41. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing the '109 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1 and 4 of the '109 Patent.

42. Claims 1 and 4 of the '109 Patent are invalid for failing to satisfy one or more of the conditions of patentability set forth in Title 35 of the United States Code.

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43. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the validity of the asserted claims of the '109 Patent within the meaning of 28 U.S.C. § 2201.

44. Therefore, a judicial declaration of invalidity of the '109 Patent is necessary and appropriate in order to resolve this controversy.

COUNT VI

Declaratory Judgment

(Non-Infringement of U.S. Patent No. 6,631,109)

45. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

46. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing certain claims of the '109 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1 and 4 of the '109 Patent.

47. None of ASUSTEK's products infringe claims 1 and 4 of the '109 Patent.

48. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the infringement of the asserted claims of the '109 Patent within the meaning of 28 U.S.C. § 2201.

49. Therefore, a judicial declaration of non-infringement of the '109 Patent is necessary and appropriate in order to resolve this controversy.

COUNT VII

Declaratory Judgment

(Invalidity of U.S. Patent No. 6,661,755)

50. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

51. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing the '755 Patent have created in ASUSTEK an objectively

reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1-3 of the '755 Patent.

52. Each of the asserted claims of the '755 Patent is invalid for failing to satisfy one or more of the conditions of patentability set forth in Title 35 of the United States Code.

53. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the validity of the asserted claims of the '755 Patent within the meaning of 28 U.S.C. § 2201.

54. Therefore, a judicial declaration of invalidity of the '755 Patent is necessary and appropriate in order to resolve this controversy.

COUNT VIII

Declaratory Judgment

(Non-Infringement of U.S. Patent No. 6,661,755)

55. The averments of paragraphs 1-19 are repeated and re-alleged as though set forth in full herein.

56. RICOH's actions, conduct and the totality of the circumstances outlined above accusing ASUSTEK of infringing certain claims of the '755 Patent have created in ASUSTEK an objectively reasonable apprehension of RICOH filing suit against ASUSTEK alleging infringement of claims 1-3 of the '755 Patent.

57. None of ASUSTEK's products infringe the asserted claims of the '755 Patent.

58. For at least these reasons, a substantial, continuing and actual controversy now exists between ASUSTEK and RICOH as to the infringement of the asserted claims of the '755 Patent within the meaning of 28 U.S.C. § 2201.

59. Therefore, a judicial declaration of non-infringement of the '755 Patent is necessary and appropriate in order to resolve this controversy.

REQUEST FOR RELIEF

WHEREFORE ASUSTEK PRAYS FOR THE FOLLOWING RELIEF:

A. A declaration that ASUSTEK's products have not and do not infringe any of the asserted claims of any patent-in-suit;

B. A declaration that each asserted claim of the PATENTS-IN-SUIT is invalid;

C. A permanent injunction enjoining RICOH, its respective officers, agents, servants, employees, attorneys and all persons and entities acting in concert with any of them from making any claim to any person or entity that ASUSTEK's products infringe any claim of the PATENTS-IN-SUIT;

D. A permanent injunction enjoining RICOH, its respective officers, agents, servants, employees, attorneys and all persons and entities acting in concert with any of them from interfering with or threatening to interfere with, the manufacture, sale, license or use of ASUSTEK's products by ASUSTEK, its distributors, customers, licensees, successors or assigns and others;

E. A permanent injunction enjoining RICOH, its respective officers, agents, servants, employees, attorneys and all persons and entities acting in concert with any of them from instituting or prosecuting any lawsuit or proceeding, or placing in issue the right of ASUSTEK, its distributors, customers, licensees, successors or assigns and others to make, use, sell, offer to sell or import ASUSTEK's products;

F. A declaration that the present action is an exceptional case under 35 U.S.C. § 285 and award ASUSTEK its attorneys' fees, costs and expenses incurred in connection with this action; and

G. Award ASUSTEK any other relief the Court deems just and proper.

DATED: April 5, 2007

PAUL, HASTINGS, JANOFSKY & WALKER LLP

By: ______________________
RONALD S. LEMIEUX

Attorneys for Plaintiffs
ASUSTEK COMPUTER INC.
AND ASUS COMPUTER INTERNATIONAL

DEMAND FOR JURY TRIAL

ASUSTEK respectfully demands a jury trial on all issues so triable pursuant to Fed. R. Civ. P. 38(b) and Civil L.R. 3-6.

DATED: April 5, 2007

PAUL, HASTINGS, JANOFSKY & WALKER LLP

By: ______________________
RONALD S. LEMIEUX

Attorneys for Plaintiffs
ASUSTEK COMPUTER INC. AND
ASUS COMPUTER INTERNATIONAL

CERTIFICATION OF INTERESTED ENTITIES OR PERSONS

Pursuant to Civil Local Rule 3-16, the undersigned certifies that as of this date, other than the named parties, there is no such interest to report.

DATED: April 5, 2007

PAUL, HASTINGS, JANOFSKY & WALKER LLP

By: ______________________
RONALD S. LEMIEUX

Attorneys for Plaintiffs
ASUSTEK COMPUTER INC.
AND ASUS COMPUTER INTERNATIONAL

LEGAL_US_W # 55985850.1

EXHIBIT A

United States Patent [19]
Shigemori
[11] Patent Number: 5,063,552
[45] Date of Patent: Nov. 5, 1991

[54] OPTICAL DISK APPARATUS WITH DATA TRANSFER RATE AND ROTATIONAL SPEED VARIABLE BY ANNULAR ZONES

[75] Inventor: Toshihiro Shigemori, Yokohama, Japan
[73] Assignee: Ricoh Company, Ltd., Tokyo, Japan

[21] Appl. No.: 375,573
[22] Filed: Jul. 5, 1989
[30] Foreign Application Priority Data
Jul. 6, 1988 [JP] Japan 63-168135
[51] Int. Cl.5 .... G11B 7/00
[52] U.S. Cl. 369/50; 369/133; 369/240
[58] Field of Search 369/32, 240, 133, 50, 369/59; 360/73.03; 358/342

[56] References Cited

U.S. PATENT DOCUMENTS

4,514,771	4/1985	Stark et al.	360/73.03
4,530,018	7/1985	Hoshino	360/72.2
4,750,059	6/1988	Syracuse	369/50 X
4,780,866	10/1988	Syracuse	369/59

Primary Examiner—Robert L. Richardson
Attorney, Agent or Firm—Cooper & Dunham

[57] ABSTRACT

A control system is provided for an optical disk driving apparatus adapted to rotate an optical disk having a plurality of tracks, and which is adapted, during the rotation of the disk, to perform optical recording and/or reproduction of information for a track which has been accessed with a light beam. The control system changes the speed f of recording/reproduction of information in accordance with the radius r of a track to be accessed in such a manner that the tracks are divided into a plurality of concentric annular blocks each having different approximate radii, and the same speed f of the recording/reproduction of information is allocated to the tracks in the same block but different speeds f of recording and/or reproduction of information are allocated to the respective blocks. The controlling system changes the speed n of rotation of the optical disk with respect to the radius r of the track to be accessed and the speed f of record/reproduction of information allocated to the block including the track to be accessed so that f/(n·r) is constant.

16 Claims, 3 Drawing Sheets

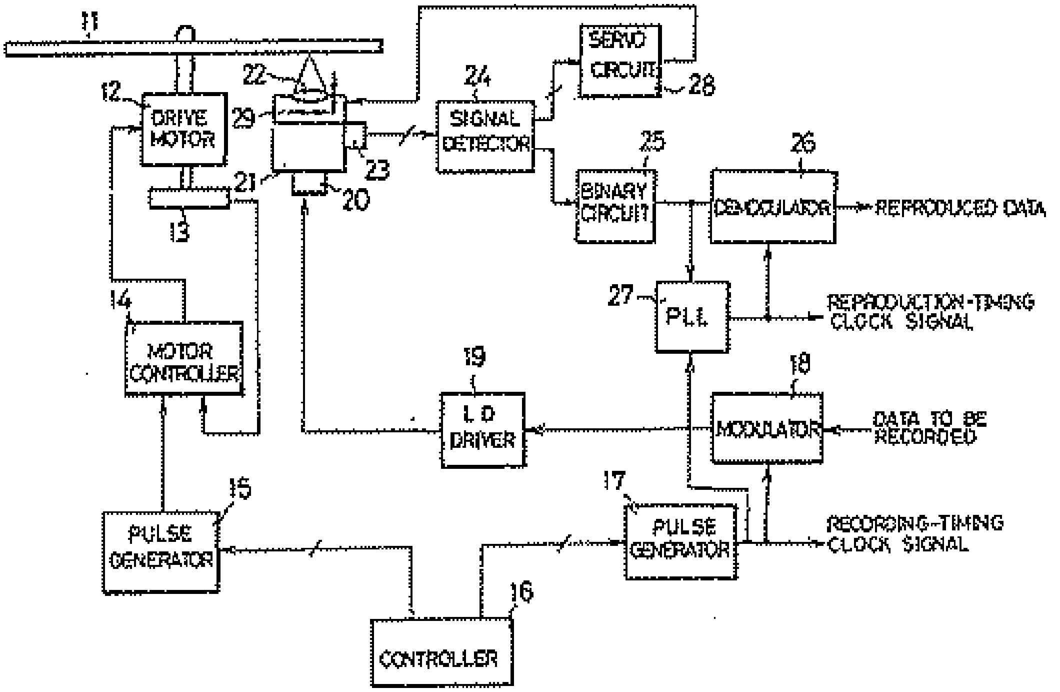
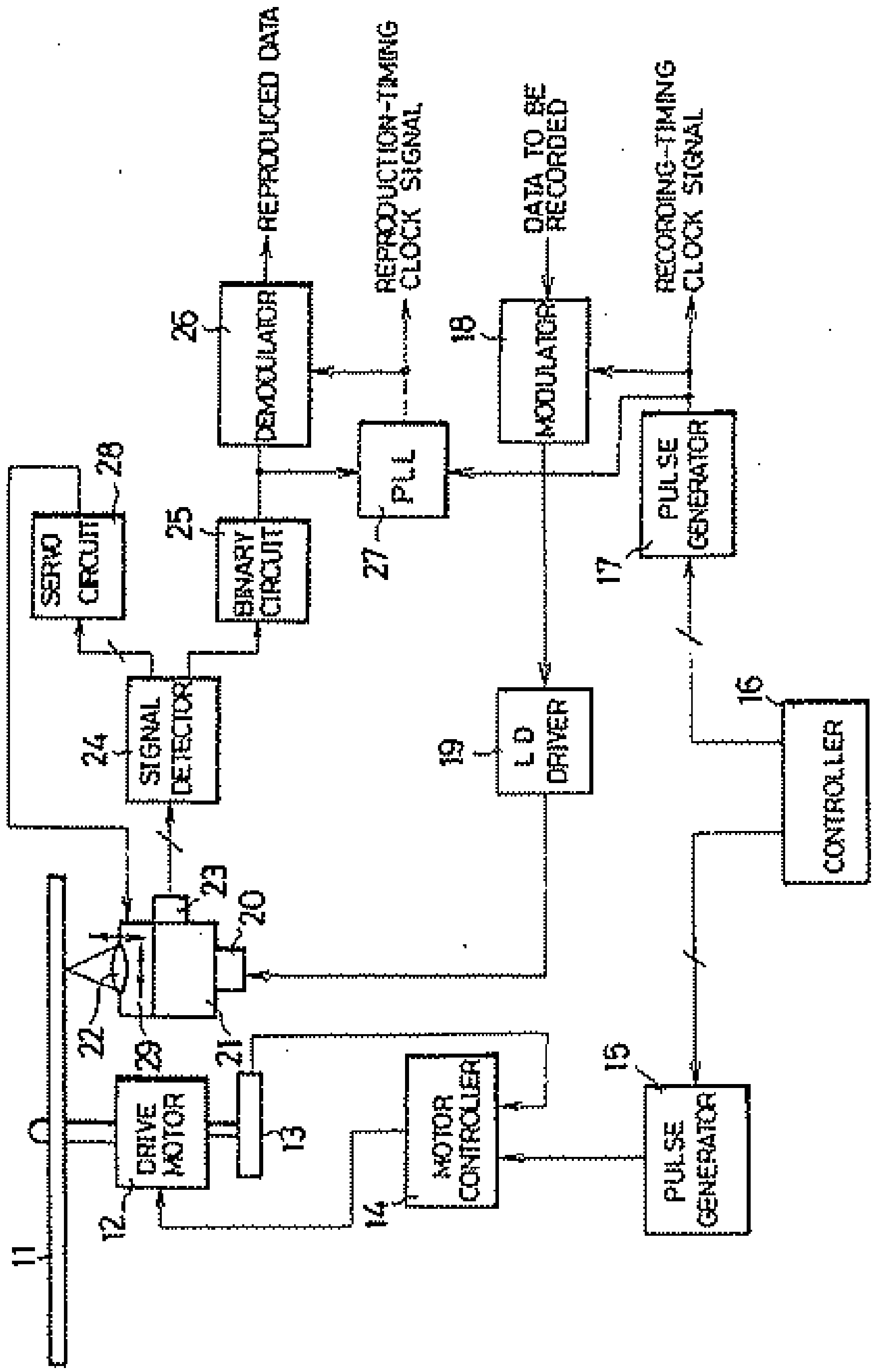


Fig. 1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DATA TO BE RECORDED
RECORDING-TIMING CLOCK SIGNAL
26
DEMODULATOR
18
MODULATOR
28
SERVO CIRCUIT
25
BINARY CIRCUIT
PLL
27
PULSE GENERATOR
17
24
SIGNAL DETECTOR
19
LD DRIVER
16
CONTROLLER
23
20
22
29
21
DRIVE MOTOR
13
12
11
14
MOTOR CONTROLLER
15
PULSE GENERATOR

Fig. 2

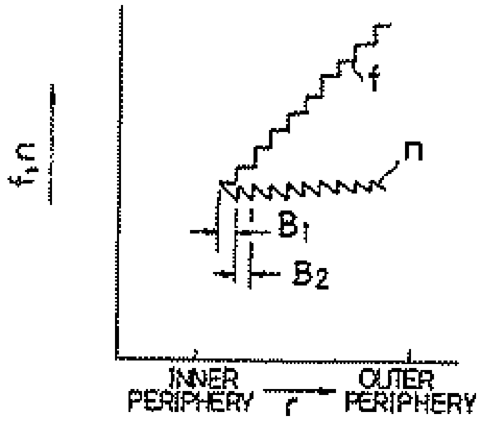


Fig. 3

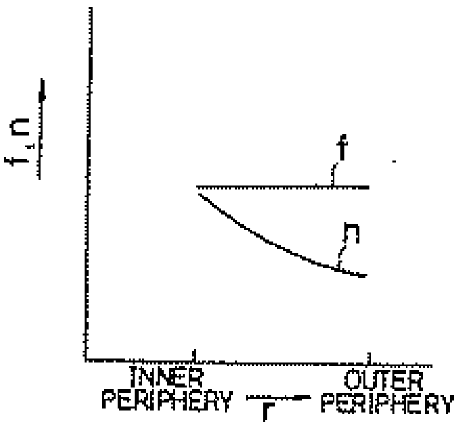


Fig. 4

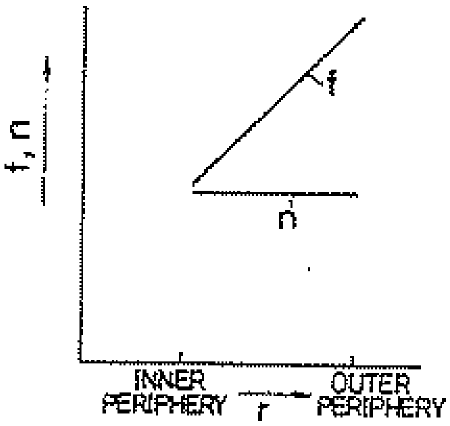
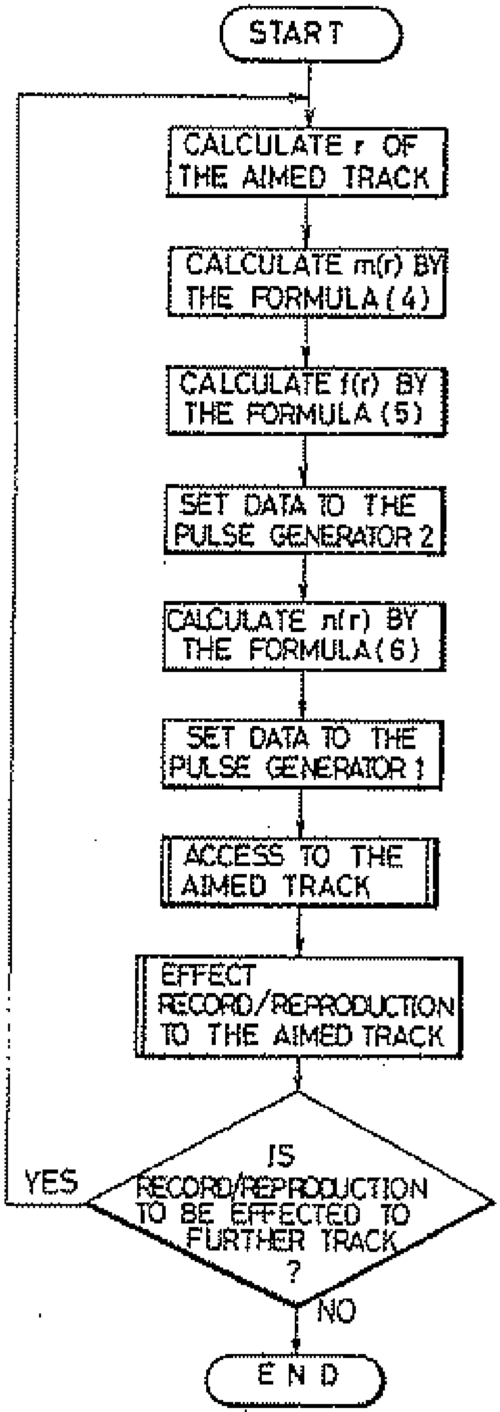


Fig.5


START
CALCULATE r OF THE AIMED TRACK
CALCULATE m(r) BY THE FORMULA (4)
CALCULATE f(r) BY THE FORMULA (5)
SET DATA TO THE PULSE GENERATOR 2
CALCULATE n(r) BY THE FORMULA (6)
SET DATA TO THE PULSE GENERATOR 1
ACCESS TO THE AIMED TRACK
EFFECT RECORD/REPRODUCTION TO THE AIMED TRACK
IS RECORD/REPRODUCTION TO BE EFFECTED TO FURTHER TRACK ?
YES
NO
END

OPTICAL DISK APPARATUS WITH DATA TRANSFER RATE AND ROTATIONAL SPEED VARIABLE BY ANNULAR ZONES

BACKGROUND OF THE INVENTION

The present invention relates generally to an optical disk driving apparatus. More particularly, the invention relates to a control system for an optical disk driving apparatus which is adapted to rotate an optical disk having a plurality of tracks, and which is adapted, during the rotation of the disk, to perform optical recording and/or reproduction of information for a track which has been accessed by a light beam impinging. It is to be noted that, in the present invention, the term "optical disk" means various kinds of optical disks such as, for example, a read-only optical disk, or a rewritable or erasable magneto-optical disk.

There are two known kinds of control systems, for defining the relationship between the rotation of an optical disk and the recording format of information on the optical disk. One is a constant angular velocity (CAV) type and the other is a constant linear velocity (CLV) type.

In an optical disk driving apparatus using a CAV system, when optical recording and/or reproduction of information for an optical disk is performed, the optical disk is rotated at a constant angular velocity. That is, the number of revolutions per unit time (i.e., rotation speed) of the optical disk is maintained constant, without relation to the radius of the tracks formed on the optical disk. Therefore, when the rate of recording and/or reproduction of information is also maintained constant, the information recording density on a given track is different from that on the other tracks, due to different linear velocities on the respective tracks, resulting in a decrease of the recording capacity of the optical disk.

On the other hand, in an optical disk driving apparatus using a CLV system, when optical record and/or reproduction of information for an optical disk is performed through an optical pickup, the rotation speed of the optical disk is varied in relation to the radii of tracks formed on the optical disk so that a constant linear velocity of the optical disk with respect to the optical pickup can be obtained on all the tracks.

It is known that when the speed of recording/reproduction of information for the optical disk is given as f (bit/sec); the radius of a track to be accessed to record and/or reproduce information is given as r (mm); and the speed of rotation of the optical disk is given as n (rps), then the information recording density b (bit/mm) on the track of the optical disk is represented by the following equation.

$$b=f/(2\pi r \cdot n) \qquad (1)$$

In an optical disk driving system using a CLV system, in order to obtain a constant information recording density b on all the tracks of the optical disk, the rotation speed n of the optical disk is changed in inverse proportion to the radius r of the tracks, while the speed f of record/reproduction of information is maintained constant.

In an optical disk driving apparatus for playback-only applications, such as a compact disk (CD) player or the like, the rotation speed of an optical disk is automatically changed by controlling the driving force of an electric drive motor for rotating the optical disk, in order to obtain a reproduction signal at a constant speed.

On the other hand, in an optical disk driving apparatus adapted to perform both optical recording and/or reproduction of information for an optical disk, it is impossible to obtain a reproduction signal with a constant speed at or before the time of information is perfomred. Accordingly, generally, according the latter system changes the rotation speed of the optical disk in steps with a relatively high resolution by using a signal output from an encoder secured to the drive motor, and the change in the rotation speed of the optical disk is regarded as a sufficiently continuous change.

In the CLV system, the recording of information is performed with a constant recording density b of information; and accordingly, it is possible to increase the recording capacity of the optical disk in comparison with that obtained by the CAV system. However, in the CLV system, it is necessary to change the rotation speed of the optical disk in accordance with the radius r of a track to be accessed for the recording and/or reproduction of information. This means that in order to effect quick access between the two tracks having significantly different radii with respect each other, it is necessary to produce a quick and significant change of the rotation speed of the optical disk. Accordingly, for the above-mentioned quick and significant change, it is necessary to use a drive motor having a large torque, causing the drive motor as well as the optical disk driving apparatus to be increased in size. For the above-mentioned accessing operation it is also necessary to supply a large amount of electric current to the drive motor, resulting in an increased electric power consumption.

On the other hand, as a method for maintaining a constant information recording density b on all the tracks of the optical disk while keeping a constant rotation speed n of the optical disk, it is possible to consider a construction in that the speed f of recording/reproduction of information is changed in proportion to the radius r of a track to be accessed, on the basis of a signal output from an encoder secured to the drive motor. However, in fact it is difficult to change the speed f of recording/reproduction of information with a necessary high resolution such that the change in the speed f of record/reproduction of information can be regarded as a sufficiently continuous change in comparison with the rotation speed n of the optical disk. Accordingly, it is difficult to realize the characteristics as described above, because the frequency of the information recording and/or reproduction signal is extremely high in comparison with that of the signal output from the encoder.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a control system for an optical disk driving apparatus which makes it possible to increase the information recording capacity of an optical disk while enabling a drive motor for rotating the optical disk to be reduced in size in comparison with that used in conventional optical disk driving apparatus using the CLV system, thereby enabling a reduction of electric power consumption.

It is further object of the present invention to provide a control system for an optical disk driving apparatus,

which enables the optical disk driving apparatus, with respect to the recording/reproduction of information, to use an optical disk interchangeable with an optical disk used in a driving apparatus using the CLV system.

The object of the invention can be achieved by a control system for an optical disk driving apparatus which is adapted to rotate an optical disk having a plurality of tracks, and which is adapted, during the rotation of the disk, to perform optical recording and/or reproduction of information for a track accessed by a light beam impinging thereon, the control system comprising:

means for changing the speed f of recording and/or reproduction of information in accordance with the radius r of a track to be accessed in such a manner that the tracks are divided into a plurality of concentric annular blocks defined by respective radii, and the same speed f of the record and/or reproduction of information is allocated to the tracks in the same block, and that different speeds f of record and/or reproduction of information are allocated to the respective blocks so as to change in proportion to the change of the radii defining the blocks; and

means for changing the speed n of rotation of the optical disk in accordance with the radius r of the track to be accessed and the speed f of record and/or reproduction of information allocated to the block including the track to be accessed so that f/(n·r) is constant.

According to the present invention having the above-mentioned construction, the tracks on the optical disk are divided into a plurality of concentric annular blocks defined by respective radii. Different values of the speed f of record/reproduction of information are allocated to the respective blocks in such a manner that the speed f of record/reproduction of information changes in steps in proportion to the radii defining the blocks, and that the same value of the speed f of record/reproduction of information is allocated to the tracks in the same block.

On the other hand, the rotation speed n of the optical disk is controlled by the controller so that with respect to the speed f of recording/reproduction of information allocated to the block including the selected track having the radius r, the rotation speed n of the disk satisfies the condition that f/(n·r) is constant.

This means that it is only necessary to change the rotation speed n of the optical disk within a limited narrow region close to a fixed value. Accordingly, it is possible to provide a coarse adjustment with a low resolution on the speed f of record/reproduction of information in proportion to the change of the approximate radii of the blocks, and it is also possible to provide a fine adjustment with a high resolution on the rotation speed n of the optical disk within a limited narrow region around a fixed value so as to obtain a constant recording density of information on the optical disk.

Accordingly, the need to change the rotation speed of the drive motor during the accessing operation, can be reduced in comparison with a conventional optical disk driving apparatus using the CLV system.

Further, since the information recording density is maintained constant on every track of the optical disk, due to the above-mentioned control for the speed f of recording/reproduction of information and the rotation speed n of the optical disk, it is possible to provide the optical disk with substantially the same recording capacity of information as that obtained by the optical disk driving apparatus using the CLV system.

Accordingly, the present invention makes it possible to increase the recording capacity of an optical disk with a small-sized drive motor for rotating the optical disk in comparison with that used in conventional optical disk driving apparatus using the CLV system, thereby enabling a reduction in electric power consumption.

Further, it is also possible, according to the present invention, to use an optical disk having a recording format which is the same as that applied to an optical disk driving apparatus using CLV system. Therefore, with respect to the recording/reproduction of information, the optical disk driving apparatus provided with the control system according to the present invention can use interchangeable optical disks with an optical disk driving apparatus using the CLV system.

Further objects, features and advantages of the present invention will become apparent from the following description of the preferred embodiments of the present invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a optical disk driving apparatus provided with a control system according to a preferred embodiment of the present invention;

FIG. 2 is a graph for explaining a relationship between the radius of a track of the optical disk, the speed of recording/reproduction of information, and the rotation speed of the optical disk, in the optical disk driving apparatus shown in FIG. 1;

FIG. 3 is a graph for explaining a relationship between the radius of a track of the optical disk, the speed of recording/reproduction, and the rotation speed of the optical disk, in a conventional optical disk driving apparatus using a CLV system;

FIG. 4 is a graph for explaining a relationship between the radius of a track of the optical disk, the speed of recording/reproduction of information, and the rotation speed of the optical disk, in an optical disk driving apparatus maintaining a constant information recording density while keeping a constant rotation speed of the optical disk; and

FIG. 5 is a flow chart for explaining the operation of the control system in the optical disk driving apparatus shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is schematically shown a construction of an optical disk driving apparatus according to a preferred embodiment of the present invention, in which an optical disk 11 has a plurality of concentric circular recording tracks. Alternatively, a plurality of recording tracks may be formed on the optical disk in the form of a continuous spiral.

The optical disk 11 is connected to and driven by a drive motor 12 for rotation about the center thereof. Also connected to the drive motor 12 opposite to the optical disk 11 is a rotary encoder 13 which generates a clock signal in accordance with the rotation of the drive motor 12.

A motor controller 14 is provided to control an electric drive current to be supplied to the motor 12 so as to cause the clock signal output from the encoder 13 to be equalized in frequency with that of a clock signal generated by a pulse generator 15.

The pulse generator 15 is controlled by a controller 16 in such a manner that the clock signal to be output from the pulse generator 15 is changed in accordance with a set data applied thereto from the controller 16. Namely, the controller 16 is capable of changing the frequency of the clock signal to be output from the pulse generator 15 in accordance with the radius r of the track of the optical disk 11 at a recording and/or reproducing position thereon, thereby changing the rotation speed n (i.e., the number of revolutions per unit time) of the drive motor 12, as shown in FIG. 2.

Another pulse generator 17 is provided which can generate a clock signal for indicating the speed of recording/reproduction of information. The pulse generator 17 is controlled by a controller 16 in such a manner that the clock signal to be output from the pulse generator 17 is changed in accordance with a set data applied thereto from the controller 16. Namely, the controller 16 is capable of changing the frequency of the clock signal to be output from the pulse generator 17 in accordance with the radius r of a track to be accessed, thereby changing the speed f of record/reproduction of information, as shown in FIG. 2.

In the case where the recording of optical information is performed, the data to be recorded is sent from the data source (not shown) synchronized with the clock signal from the pulse generator 17, to a modulator 18 in which the synchronized data is modulated by, for example, a method of modified frequency modulation (MFM). The modulated output signal from the modulator 18 is supplied to a laser diode (LD) driver 19 for driving a laser diode (LD) 20, so that the intensity of a light beam to be emitted from the laser diode (LD) 20 is changed with the output signal from the modulator 18.

The LD 20 is secured to an optical pickup 21 which is provided with an optical system including an object lens 22. The light beam emitted from the LD 20 is directed to the selected track of the optical disk 11 through the optical system including the object lens 22, by which information is recorded on the selected track of the optical disk 11.

On the other hand, in the case where the reproduction of information is performed, the LD driver 19, which is not supplied with the data to be recorded, causes the LD 20 to emit a light beam with a fixed intensity which is predetermined for the reproduction of information. The light beam emitted from the LD 20 is directed to the track of the optical disk 11 through the optical system including the object lens 22 and is reflected by the optical disk 11.

The reflected light beam passes though the optical system including the object lens 22, and is detected by a photodetector 23. The detected light is then converted by a signal detector 24 to an electric signal. The electric signal is then converted by a binary circuit 25 to a binary signal which is then demodulated by a demodulator 26, thereby being converted to reproduced data.

A phase locked loop (PLL) circuit 27 is provided for generating a reproduction-timing clock signal. More specifically, the PLL circuit 27 is operated so as to be synchronized with the clock signal output from the pulse generator 17, thereby generating a reproduction-timing clock signal which is so predetermined as to correspond to a standard reproduction speed, until the reproduction of information is started. During the information reproducing operation, the PLL circuit 27 is operated so as to be synchronized with the clock signal output from the binary circuit 25, thereby generating a reproduction-timing clock signal which changes with fluctuations in the information reproduction speed due to irregular rotation of the drive motor 12 or the like.

Similarly to a conventional configuration, the photodetector 23 is divided into a plurality of sections, each of which is adapted to produce a light-detecting signal.

In addition to the above-mentioned detection of recorded data encoded in the light reflected from the optical disk, the signal detector 24 is also adapted to detect errors in focus of the light beam spot on the track of the optical disk 11 (focusing error), and errors in position of the light beam spot on the track of the optical disk 11 (tracking error), by an appropriate calculation from the signals output from the photodetector sections. The signal detector 24 produces servo signals corresponding to the amount of detected focusing error and to the amount of detected tracking error, respectively. The above-mentioned light beam spot is produced by the object lens 22 which is able to converge the light beam emitted from the LD 20.

A servo circuit 28 is provided for controlling a drive current to be supplied to an actuator 29 adapted to drive the object lens 22, in accordance with the servo signals output from the signal detector 24, so that the light beam spot is always accurately in focus on the aimed track on the optical disk 11.

Similarly to a conventional configuration, a seek mechanism (not shown) is provided for accessing the optical pickup 21 to a desired track on the optical disk 11 by moving the optical pickup 21 in the radius direction of the optical disk 11.

FIG. 2 shows relationships between the radius r of the track of the optical disk 11, the information recording and/or reproduction speed f, and the rotation speed n (i.e., the number of revolutions per unit time) of the optical disk 11, which is obtained by the operation of the controller 16 shown in FIG. 1.

Comparing with FIG. 2, similar relationships between the radius r, the information recording and/or reproduction speed f, and the rotation speed n in a CLV system and in the optical disk driving system maintaining a constant information recording density while keeping a constant rotation speed of the optical disk are shown in FIG. 3 and in FIG. 4 respectively. In FIG. 3, it shows that the change of rotation speed n of the optical disk is inversely proportional to the radius r of the tracks, while the speed f of recording and/or reproduction is kept constant. In FIG. 4, it shows that the change of speed f of recording and/or reproduction is proportional to the radius r of the track to be accessed, while the rotation speed n of the optical disk is kept at a constant.

In this embodiment as shown in FIG. 2, the recording surface of the optical disk 11 is divided into a plurality of concentric annular blocks B1, B2 . . . defined by respective radii. Different speeds f of record/reproduction of information are allocated to the blocks B1, B2 . . . , respectively, in such a manner that the speed f of record/reproduction of information changes in proportion to the radii defining the blocks, and that the same speed f of record/reproduction of information is allocated to the tracks existing in the same block.

On the other hand, the rotation speed n of the optical disk 11 is controlled by the controller 16 so that the information recording density b of the optical disk 11, i.e., the value obtained by above-mentioned equation (1), is maintained constant. This means that is is only necessary to change the rotation speed n of the optical

disk 11 within a limited narrow region around a fixed value, as shown in FIG. 2.

Accordingly, in this embodiment, it is possible to provide a coarse adjustment with a low resolution on the speed of record/reproduction of information, which is generally difficult to change with a high resolution, in proportion to the change of the radii defining the blocks, and it is also possible to provide a fine adjustment with a high resolution on the rotation speed n of the optical disk, which is generally easy to change with a high resolution, within a limited narrow region around a fixed value so as to provide a substantially constant information recording density b on all the tracks of the optical disk 11.

As the result, the need to change the of rotation speed of the drive motor 12 during the accessing operation can be reduced in comparison with a conventional optical disk driving apparatus using the CLV system, enabling the drive motor 12 to be decreased in size and thus resulting in a reduction in an electric power consumption.

Further, similarly to an optical disk driving apparatus using the CLV system, the information recording density is maintained at a fixed value on every track on the optical disk 11. Accordingly, it is possible to use an optical disk having the same recording capacity as that obtained by the optical disk driving apparatus using the CLV system. Further, a recording format which is the same as that applied to an optical disk driving apparatus using CLV system, can be applied to the optical disk 11 which is to be used for the optical disk driving apparatus shown in FIG. 1. Namely, with respect to the recording/reproduction of information, the optical disk driving apparatus having a control system according to this embodiment has can use optical disks interchangeable with the optical disks used in an optical disk driving apparatus using the CLV system.

FIG. 5 is a flow chart for explaining the operation of the controller 16 which is adapted to obtain the relationship between the speed of recording/reproduction of information and the rotation speed n of the optical disk 11, shown in FIG. 2.

In this embodiment, for the sake of clarity of description, it is decided that the width Δr (mm) of each of the blocks in the radial direction of the optical disk is given as a quotient obtained by dividing the radius r_0 (mm) of the innermost track of the optical disk by an appropriate positive integer. Namely, the width Δr (mm) is obtained by the following equation.

$$\Delta r = r_0/m_0 \qquad (2)$$

(m_0: integer)

Similarly, when the speed of record/reproduction of information on the innermost track of the optical disk is represented as f_0 (bit/sec), the increment Δf (bit/sec) of the speed f of record/reproduction of information is obtained by the following equation.

$$\Delta f = f_0/m_0 \qquad (3)$$

As shown in FIG. 6, after the radius r (mm) of a target track which is to be accessed for the recording/reproduction of information is calculated on the basis of an access data(not shown), the integer m(r) is calculated from the following equation.

$$m(r) = \mathrm{int}(r/\Delta r) \qquad (4)$$

Here, a function int(x) of a given real number x gives a maximum integer which is less than the real number x. Namely, according to this function int(x), the maximum integer is obtained by omitting figures below the decimal point from the real number. Accordingly, an integer m(r) obtained by the equation (4) indicates a block to which the track to be recorded on or reproduced from belongs.

Next, the speed of recording/reproduction of information f(r) on that block is calculated by the following equation.

$$f(r) = m(r)\cdot\Delta f \qquad (5)$$

Then, the set data to be sent from the controller 16 to the pulse generator 17 (i.e., the pulse generator 2 in FIG. 5) is adjusted so as to become equal to the calculated speed f(r).

Next, a disk rotation speed n(r) for obtaining a constant recording density b of information is calculated by the following equation.

$$n(r) = f(r)/(2\pi\cdot b\cdot r) \qquad (6)$$

Then, the set data to be sent from the controller 16 to the pulse generator 15 (i.e., the pulse generator 1 in FIG. 5) is adjusted so as to become equal to the calculated speed n(r).

Thereafter, the optical pickup 21 is moved to the target track, and information recording and/or reproduction is performed by the optical information recording and/or reproducing system at the target track on the optical disk 11.

In this way, by executing repeatedly the process shown in FIG. 5, the relationship between f, n, and r, as shown in FIG. 2, is maintained, and accordingly, a constant recording density b is obtained on the tracks of the optical disk.

Many widely different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

What is claimed is:

1. A method for controlling an information recording and/or reproduction speed "f" and a rotation speed "n" of an optical disk used in an information recording and/or reproduction device, said optical disk having a plurality of tracks in the form of concentric circles or a spiral, said information recording and/or reproduction device being adapted to access said tracks by means of a light beam while rotating said optical disk, thereby to optically record information on or reproduce information from said tracks, said method comprising the steps of:

dividing said tracks into a plurality of concentric annular blocks which are different in radius from each other;

changing said information recording and/or reproduction speed "f" in accordance with the radius of a track to be accessed in such a manner that said recording and/or reproduction speed "f" is constant within a block but different as between said blocks depending on the block radii; and

changing said rotation speed "n" of said optical disk in such a manner that $f/(n \cdot r)$ is constant, where "r" is the radius of said track to be accessed.

2. A method according to claim 1, wherein the widths "Δr" of adjacent blocks are identical with each other with respect to a radial direction of said disk.

3. A method according to claim 2, wherein the width "Δr" of a block in the radial direction is determined in accordance with:

$$\Delta r = r_0/m_0$$

where "r_0" is the radius of the innermost track of the disk and "m_0" is a predetermined integer.

4. A method according to claim 3, wherein said step of changing said speed "f" comprises changing said speed "f" in steps with a constant increment Δf which is determined in accordance with:

$$\Delta f = f_0/m_0$$

where "f_0" is an information recording and/or reproduction speed allocated to the innermost track of the disk.

5. A method according to claim 4, wherein said speed "f" to be allocated to a block including the track to be accessed is determined in accordance with:

$$f = m(r) \cdot \Delta f$$

where "m(r)" represents a maximum integer less than said radius "r" of said track to be accessed and is determined in accordance with:

$$m(r) = Int(r/\Delta r).$$

6. A method according to claim 5, wherein said speed "n" is determined to satisfy the following condition with respect to said radius "r" of said track to be accessed and said speed "f" allocated to the block including said track to be accessed:

$$n = f/(2\pi rb)$$

where "b" represents a desired information recording density.

7. A method according to claim 1, wherein said tracks are concentrically arranged on said disk about the center of said disk.

8. A method according to claim 1, wherein said tracks are substantially concentrically arranged on said disk in the form of a continuous spiral.

9. An apparatus for controlling an information recording and/or reproduction speed "f" and a rotation speed "n" of an optical disk used in an information recording and/or reproduction device, said optical disk having a plurality of tracks in the form of concentric circles or a spiral, said information recording and/or reproduction device being adapted to access said tracks by means of a light beam while rotating said optical disk, thereby to perform an optical recording and/or reproduction with respect to said tracks, said apparatus comprising:

a dividing means for dividing said tracks into a plurality of concentric annular blocks which are different in radius from each other;

a first changing means for changing said information recording and/or reproduction speed "f" in accordance with a radius of said track in such a manner that said speed "f" is constant within a block but is different as between different blocks and depends on the radii of the blocks; and

a second changing means for changing said rotation speed "n" of said optical disk in such a manner that $f/(n \cdot r)$ is constant, where "r" is the radius of said track to be accessed.

10. An apparatus according to claim 9, wherein the widths "Δr" of adjacent blocks are identical with each other with respect to a radial direction of said disk.

11. An apparatus according to claim 10, wherein said width "Δr" is determined in accordance with:

$$\Delta r = r_0/m_0$$

where "r_0" is the radius of the innermost tracks on the disk and "m_0" is a predetermined integer.

12. An apparatus according to claim 11, wherein said first changing means comprises a means for changing said speed "f" in steps with a constant increment "Δf" which is determined in accordance with:

$$\Delta f = f_0/m_0$$

where "f_0" is an information recording and/or reproduction speed allocated to the innermost track on the disk.

13. An apparatus according to claim 12, wherein said speed "f" to be allocated to the block including said track to be accessed is determined in accordance with:

ii $f = m(r) \cdot \Delta f$

where "m(r)" represents a maximum integer less than said radius "r" of said track to be accessed and is determined in accordance with:

$$m(r) = Int(r/\Delta r).$$

14. An apparatus according to claim 13, wherein said speed "n" is determined to satisfy the condition with respect to said radius "r" of said track to be accessed and said speed "f" allocated to the block including said track to be accessed:

$$n = f/(2\pi rb)$$

where "b" represents a desired information recording density.

15. An apparatus according to claim 14, wherein said tracks are concentrically arranged on said disk about the center of said disk.

16. An apparatus according to claim 9, wherein said tracks are substantially concentrically arranged on said disk in the form of a continuous spiral.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,063,552

DATED : November 5, 1991

INVENTOR(S) : Toshihiro Shigemori

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10, line 39, (Claim 13), delete "ti"; and

Column 10, line 56, (Claim 15), change "claim 14" to --claim 9--.

Signed and Sealed this

Thirteenth Day of July, 1993

Attest:

Michael K. Kirk

MICHAEL K. KIRK

Attesting Officer

Acting Commissioner of Patents and Trademarks

EXHIBIT B

US006172955B1

(12) **United States Patent**
Hashimoto

(10) **Patent No.:** **US 6,172,955 B1**
(45) **Date of Patent:** **Jan. 9, 2001**

(54) OPTICAL DISC RECORDING AND REPRODUCING APPARATUS FOR PERFORMING A FORMATTING PROCESS AS A BACKGROUND PROCESS AND A METHOD FOR FORMATTING AN OPTICAL DISC BY A BACKGROUND PROCESS

(75) Inventor: Hirokuni Hashimoto, Kanagawa (JP)

(73) Assignee: Ricoh Company, Ltd., Tokyo (JP)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: 09/135,888

(22) Filed: Aug. 18, 1998

(30) Foreign Application Priority Data

Aug. 25, 1997 (JP) 9-227921

(51) Int. Cl.^{7} G11B 7/00
(52) U.S. Cl. 369/58; 369/59; 369/47
(58) Field of Search 369/47, 48, 49, 369/50, 53, 54, 58, 59, 275.3, 32

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Primary Examiner—Muhammad Edun
(74) *Attorney, Agent, or Firm*—Dickstein Shapiro Morin & Oshinsky LLP

(57) ABSTRACT

An optical disc recording and reproducing apparatus can record data, which is provided in a packet having a fixed length, on an optical disc without waiting for a long time for a completion of a formatting operation. The optical disc is formatted by a formatting process performed as a background process so that another process is acceptable after a start of the formatting process. The formatting process is performed so as to fill at least a predetermined part of a recording area of said optical disc by packets having a fixed length.

21 Claims, 8 Drawing Sheets

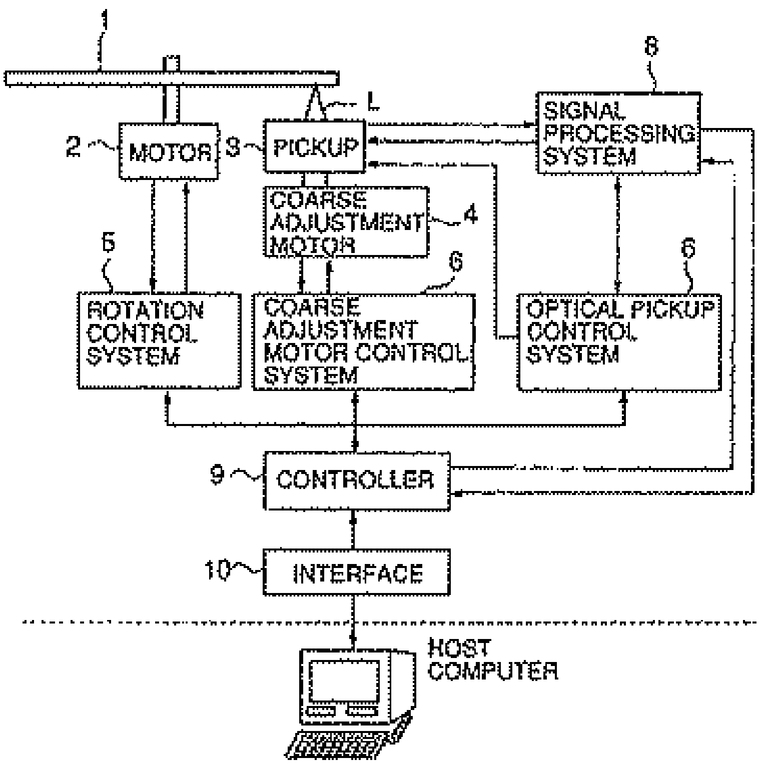


FIG.1

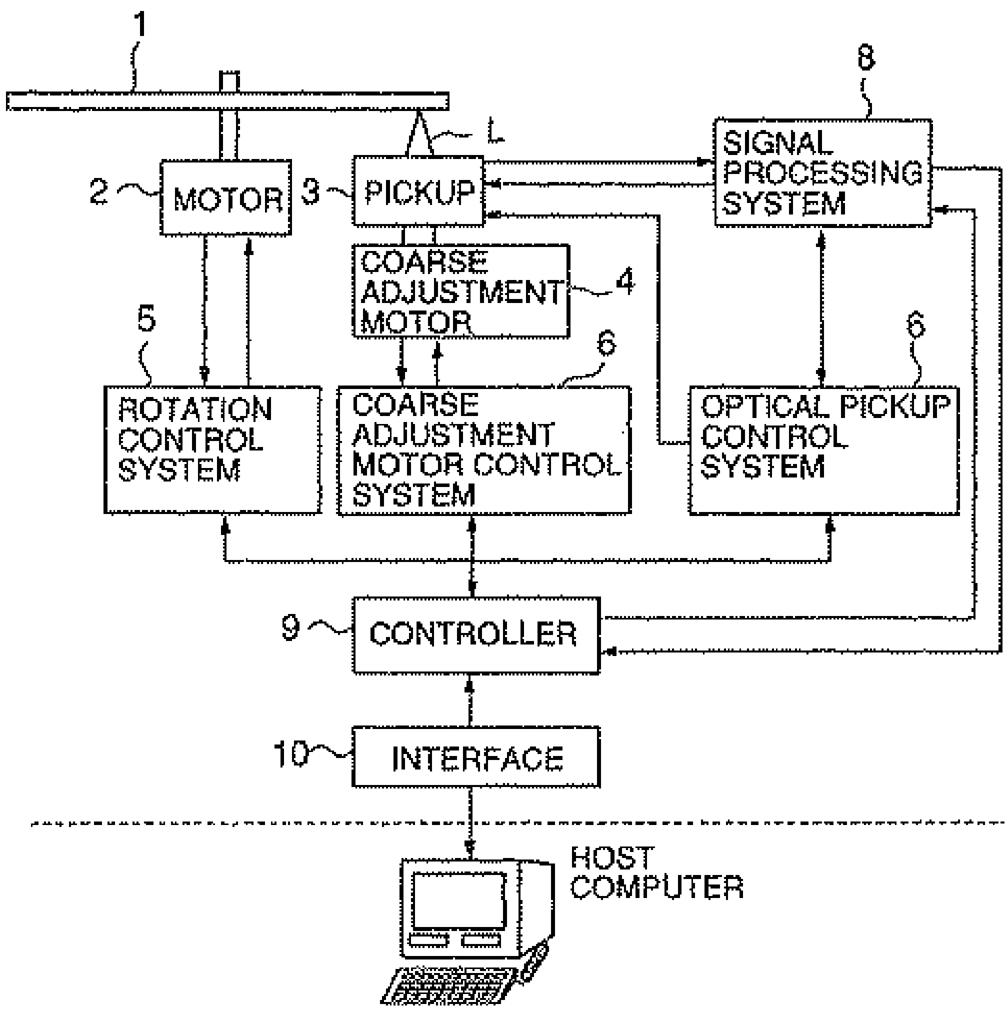

1
8
L
2
MOTOR
3
PICKUP
SIGNAL PROCESSING SYSTEM
COARSE ADJUSTMENT MOTOR
4
5
6
6
ROTATION CONTROL SYSTEM
COARSE ADJUSTMENT MOTOR CONTROL SYSTEM
OPTICAL PICKUP CONTROL SYSTEM
9
CONTROLLER
10
INTERFACE
HOST COMPUTER

FIG.2

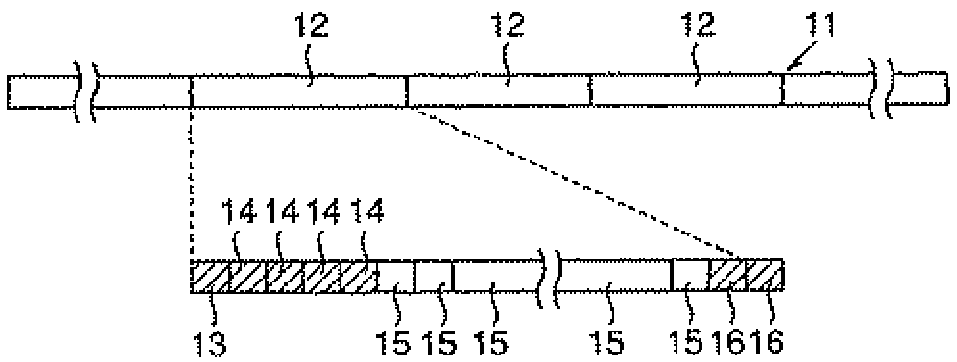

12
12
12
11
14 14 14 14
13
15 15 15
15
15 16 16

FIG.3

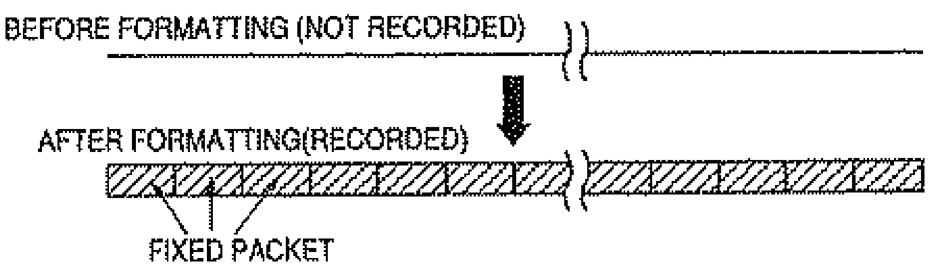

BEFORE FORMATTING (NOT RECORDED)
AFTER FORMATTING(RECORDED)
FIXED PACKET

FIG.4

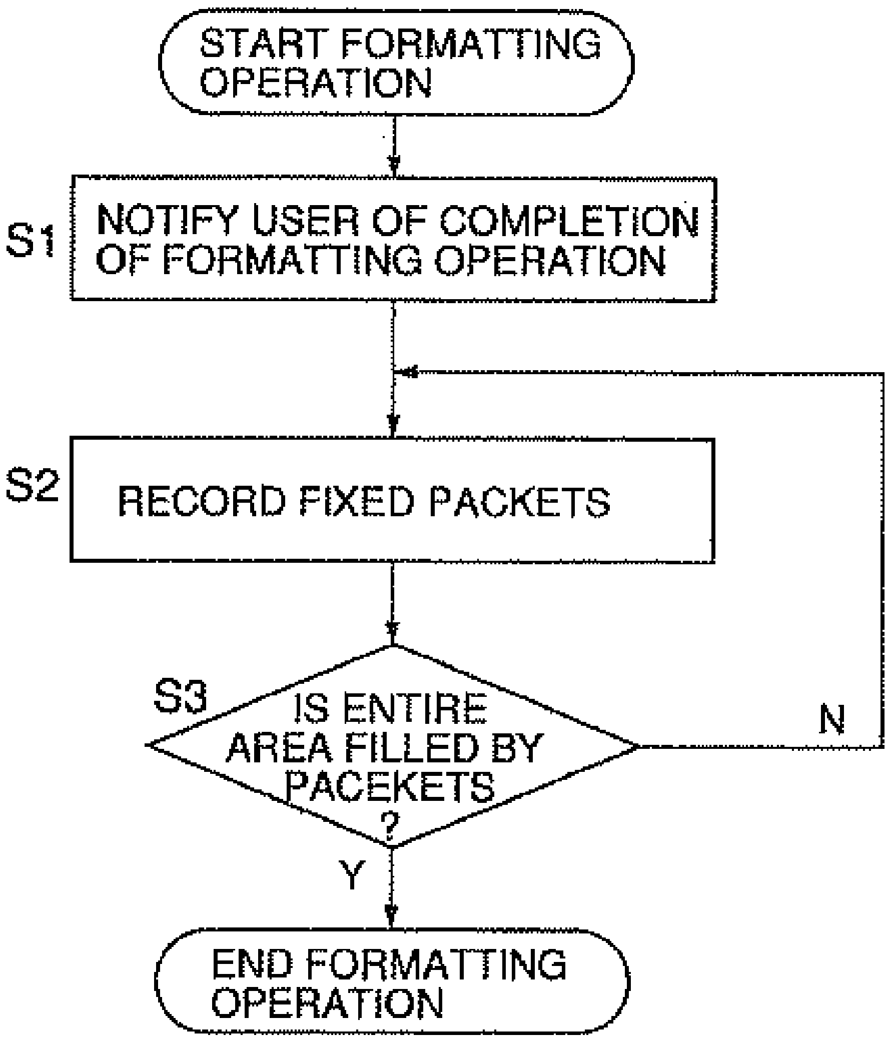

START FORMATTING OPERATION
S1
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S2
RECORD FIXED PACKETS
S3
IS ENTIRE AREA FILLED BY PACEKETS ?
N
Y
END FORMATTING OPERATION

FIG.5

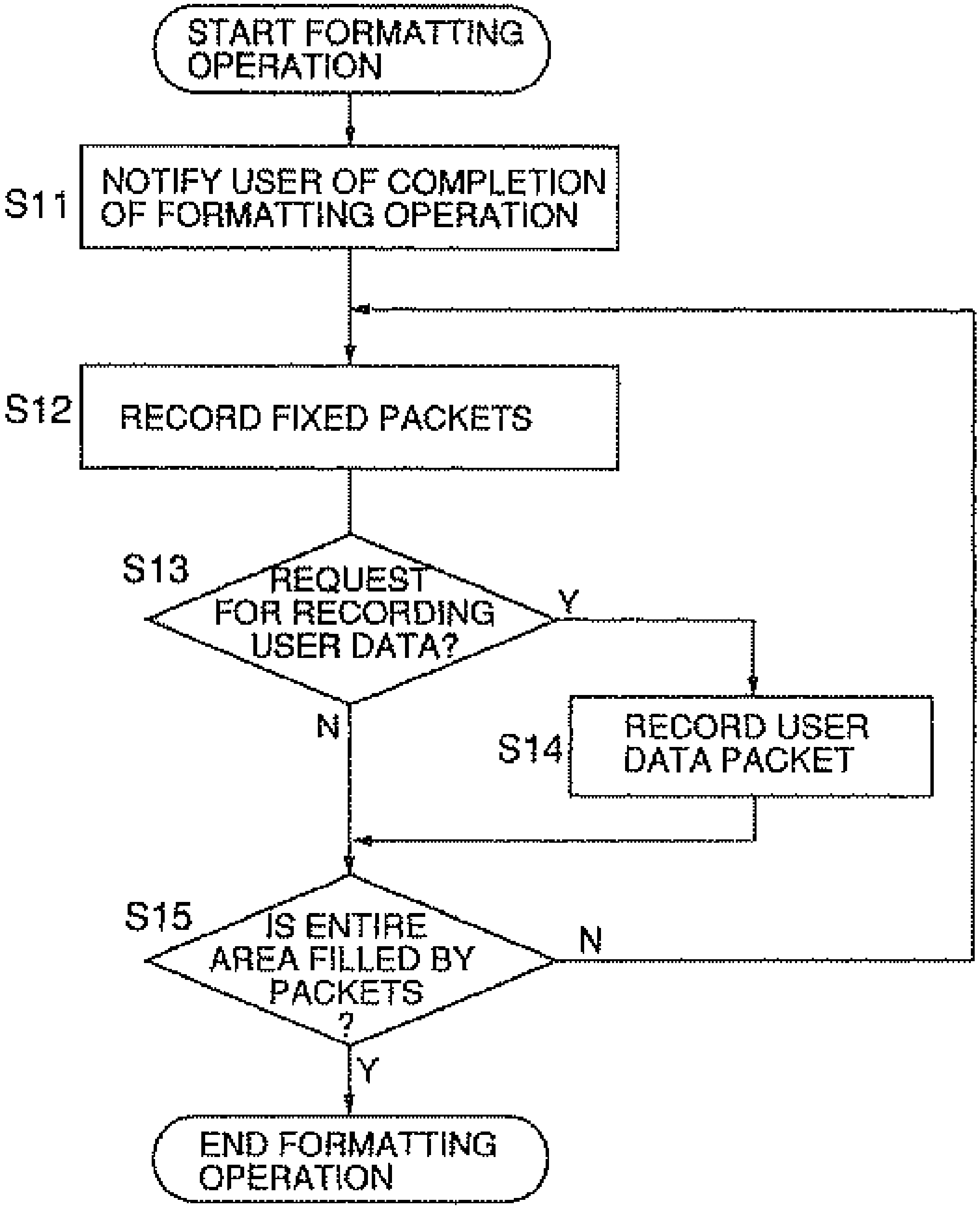
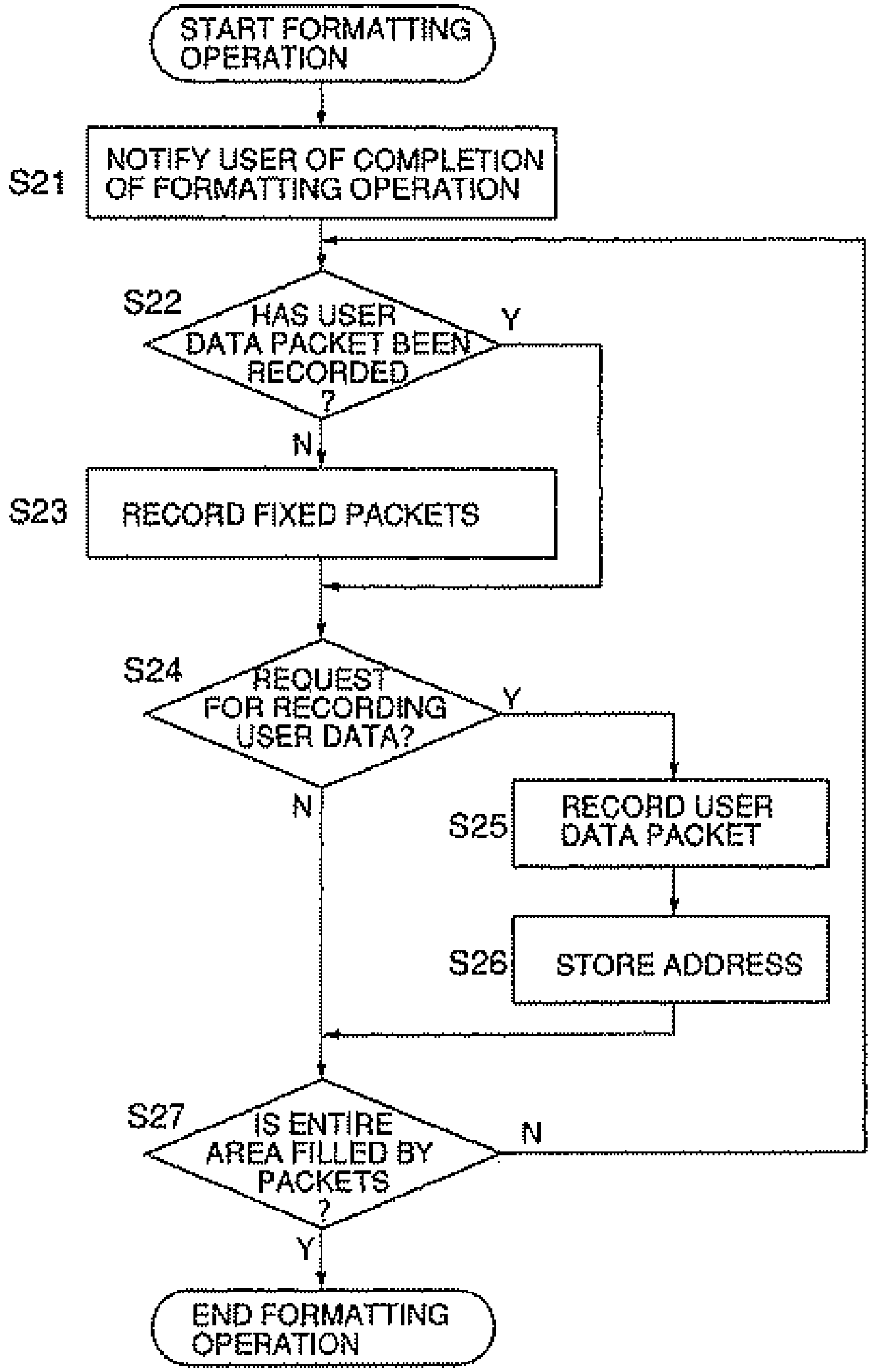

START FORMATTING OPERATION
S11
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S12
RECORD FIXED PACKETS
S13
REQUEST FOR RECORDING USER DATA?
Y
N
S14
RECORD USER DATA PACKET
S15
IS ENTIRE AREA FILLED BY PACKETS ?
N
Y
END FORMATTING OPERATION

FIG.6



START FORMATTING OPERATION
S21
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S22
HAS USER DATA PACKET BEEN RECORDED ?
Y
N
S23
RECORD FIXED PACKETS
S24
REQUEST FOR RECORDING USER DATA?
Y
N
S25
RECORD USER DATA PACKET
S26
STORE ADDRESS
S27
IS ENTIRE AREA FILLED BY PACKETS ?
N
Y
END FORMATTING OPERATION

FIG.7

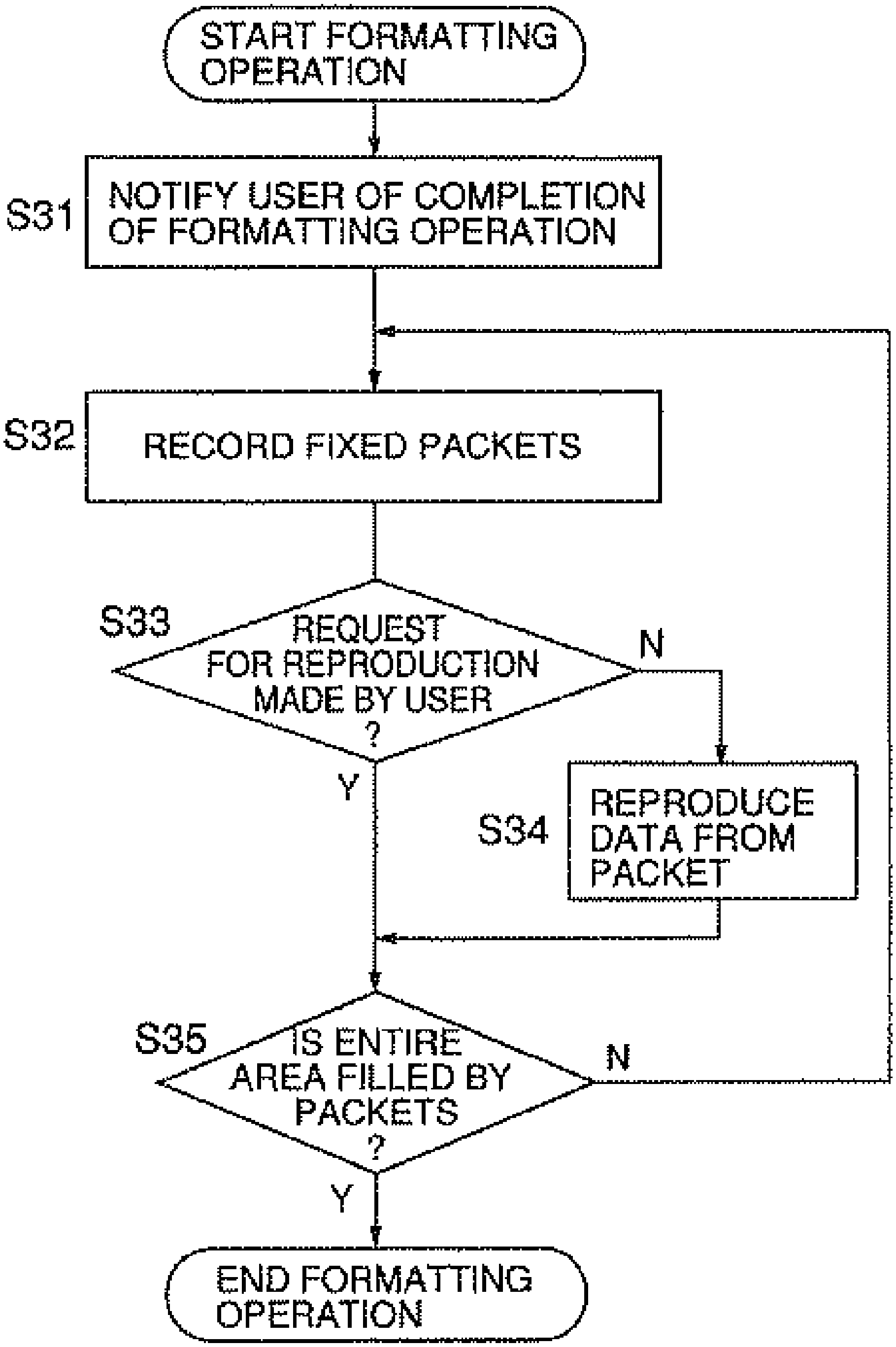

START FORMATTING OPERATION
S31
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S32
RECORD FIXED PACKETS
S33
REQUEST FOR REPRODUCTION MADE BY USER ?
N
Y
S34
REPRODUCE DATA FROM PACKET
S35
IS ENTIRE AREA FILLED BY PACKETS ?
N
Y
END FORMATTING OPERATION

FIG.8

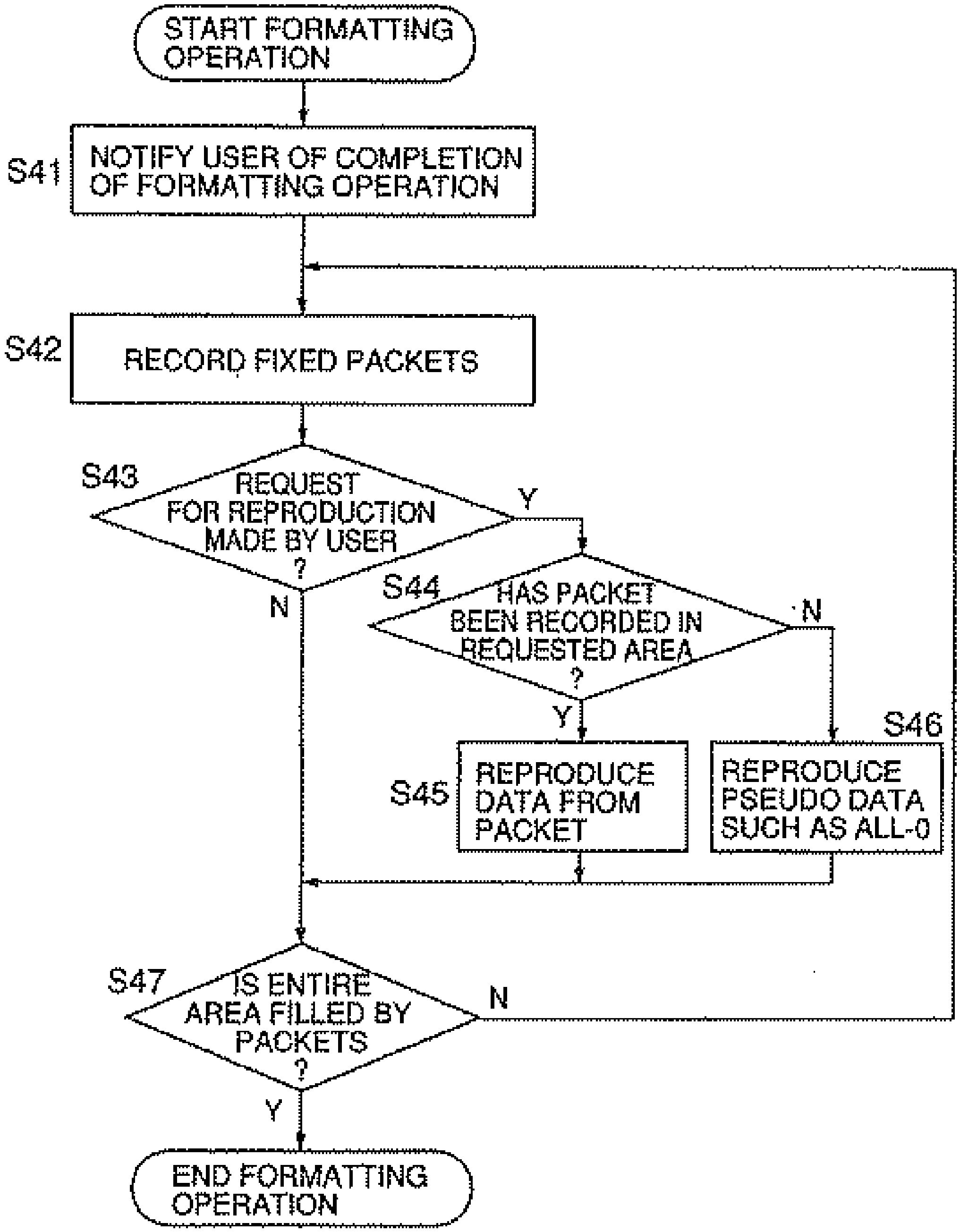
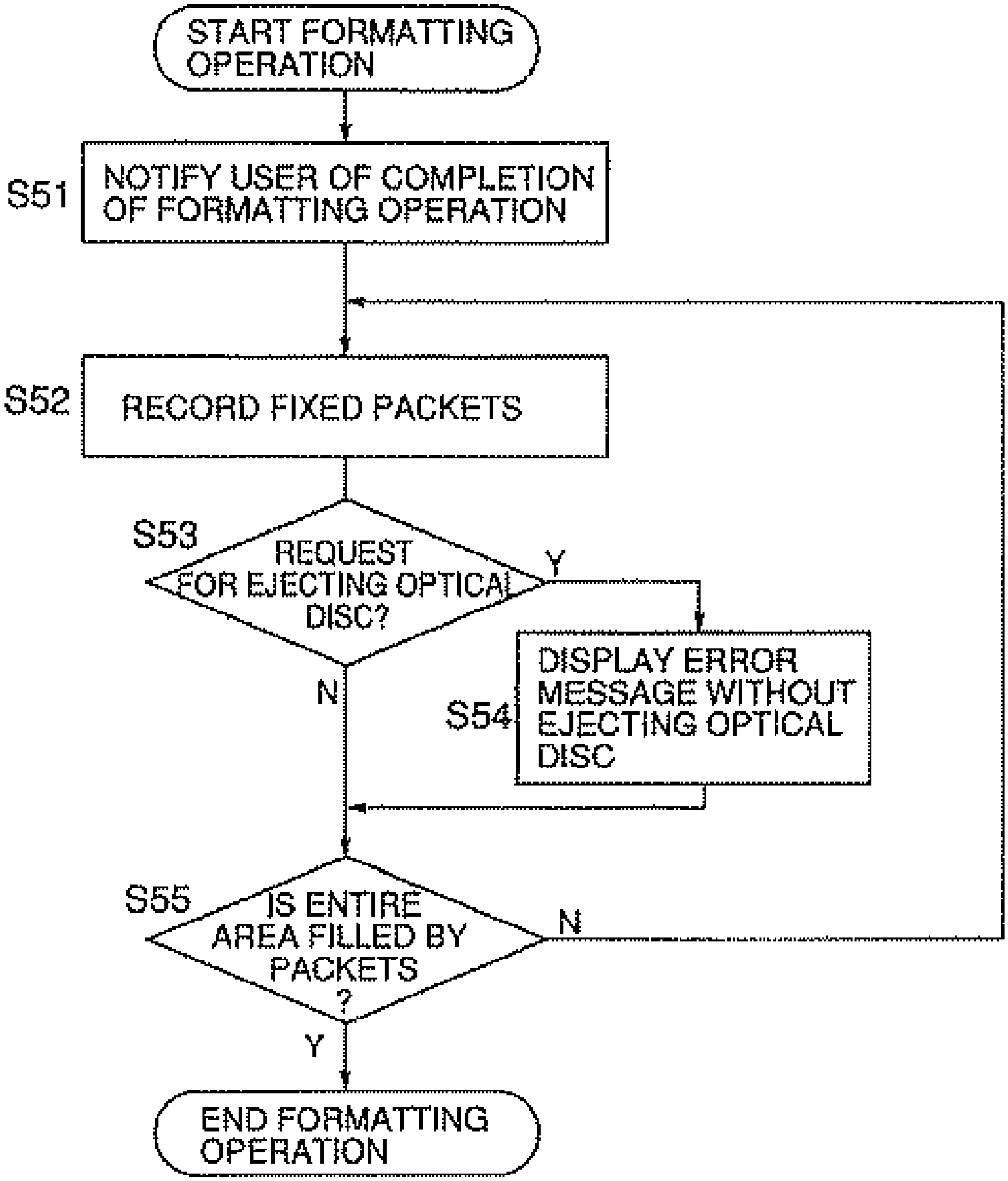

START FORMATTING OPERATION
S41
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S42
RECORD FIXED PACKETS
S43
REQUEST FOR REPRODUCTION MADE BY USER ?
Y
N
S44
HAS PACKET BEEN RECORDED IN REQUESTED AREA ?
N
Y
S45
REPRODUCE DATA FROM PACKET
S46
REPRODUCE PSEUDO DATA SUCH AS ALL-0
S47
IS ENTIRE AREA FILLED BY PACKETS ?
N
Y
END FORMATTING OPERATION

FIG.9


START FORMATTING OPERATION
S51
NOTIFY USER OF COMPLETION OF FORMATTING OPERATION
S52
RECORD FIXED PACKETS
S53
REQUEST FOR EJECTING OPTICAL DISC?
Y
N
S54
DISPLAY ERROR MESSAGE WITHOUT EJECTING OPTICAL DISC
S55
IS ENTIRE AREA FILLED BY PACKETS ?
N
Y
END FORMATTING OPERATION

OPTICAL DISC RECORDING AND REPRODUCING APPARATUS FOR PERFORMING A FORMATTING PROCESS AS A BACKGROUND PROCESS AND A METHOD FOR FORMATTING AN OPTICAL DISC BY A BACKGROUND PROCESS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to an optical disc recording and reproducing apparatus and, more particularly, to an optical disc recording and reproducing apparatus which records information on a rewritable optical disc such as a CD-RW.

2. Description of the Related Art

A minimum unit for reproduction of information recorded on a recording area of a compact disc (CD), a recordable optical disc (CD-R) or a rewritable optical disc (CD-RW) is defined as a block of a recording area. Each block can contain information of about 2,048 to 2,352 bytes.

A minimum unit for recording information on an optical disc such as a CD-R or a CD-RW is defined as a packet. Each packet comprises at least one user data block, five link blocks preceding the user data block and two link blocks subsequent to the user data block. The five link blocks preceding the user data block include one link block and four run-in blocks. The two link blocks subsequent to the user data block include two run-out blocks.

The link blocks are required for interconnecting a plurality of packets when information is recorded on an optical disc such as a CD. The link block does not contain user data. It should be noted that a rule for recording data on a CD is defined by a predetermined standard. Such a rule is referred to as a "linking rule".

There are two methods for recording data on an optical disc such as a recordable compact disc (CD-R) or a rewritable compact disc (CD-RW). One of the methods is referred to as a "track at-once method" and the other is referred to as a "packet write method".

The track at-once method is for recording information on a track all at one time by using a single packet. The user data blocks in the track are consecutive, and there are no link blocks between the user data blocks. A single track constitutes a recording unit, and ninety-nine tracks can be formed on the optical disc at maximum. A start address and an end address of each track are recorded on a separate area of the optical disc as a "table of contents (TOC)".

On the other hand, the packet write method is for recording information on a track by dividing the track into a plurality of packets so that the information is recorded on an individual packet basis. Since this method records information by each individual packet, each user data block is discretely located in a single track and link blocks are provided between adjacent ones of user data blocks.

The packet write method is classified into two types, that is, a "fixed packet write method" and a "variable packet write method". In the fixed packet write method, a number of user data blocks within a track is set to a fixed number. The number of user data blocks within a packet is referred to as a packet length or packet size. On the other hand, in the variable packet write method, packets having various packet lengths are provided in a single track.

The Universal Disc format (UDF) is a file system that uses the fixed packet write system. The UDF is used by various devices. The UDF utilizes a recording format that takes advantage of a feature of each device.

In a conventional CD-R drive such as one disclosed in Japanese Laid-Open Patent Application No.7-141660, when the recording is performed in accordance with the packet write method, data to be recorded is added to previously recorded packets since only an addition of data is allowed for the CD-R. Accordingly, the UDF uses a variable packet write method referred to as a sequential UDF which can perform a recording only by adding data after the previously recorded data. Thus, there is no need to consider a format.

On the other hand, a CD-RW drive is capable of recording data on a CD-RW by overwriting. Thus, the CD-RW drive uses a random UDF which records data by each packet unit and reproduces the data by each block.

In order to record and reproduce data at random, the random UDF requires a formatting operation by previously recording packets on the entire recording area or a designated area of the CD-RW, each of the packets having a fixed length, so that the entire recording area or the designated area are filled by the packets. By this formatting operation, data can be randomly recorded on the recording area of the CD-RW, or data recorded on the CD-RW can be randomly reproduced.

However, when the above-mentioned formatting operation is performed, it takes a long time to fill the entire recording area or the designated area of the CD-RW by the packets. Thus, there is a problem in that a recording or reproducing operation cannot be performed and completion of the formatting operation data must be waited for when the formatting operation is being performed.

The recording capacity of the CD-RW is represented by a time for continuously performing a recording operation. For example, one minute of recording corresponds to 9 megabytes, and data corresponding to about 74 minutes can be recorded on a CD-RW. Thus, it takes about 40 minutes to complete a recording of data including the TOC even if the recording is performed at a double recording speed. This means that one must wait for about 40 minutes until a formatting operation is completed in order to initially use a blank or new CD-RW.

SUMMARY OF THE INVENTION

It is a general object of the present invention to provide an improved and useful optical disc recording and reproducing apparatus in which the above-mentioned problems are eliminated.

A more specific object of the present invention is to provide an optical disc recording and reproducing apparatus which can record data, which is provided in a packet having a fixed length, on an optical disc without waiting for a long time for a completion of a formatting operation.

Another object of the present invention is to provide a formatting method for formatting a rewritable optical disc without delaying a recording operation or a reproducing operation performed on the optical disc.

In order to achieve the above-mentioned objects, there is provided according to one aspect of the present invention an optical disc recording and reproducing apparatus, comprising:

recording means for recording data on a rewritable optical disc by using a fixed packet write method;

reproducing means for reproducing data recorded on the optical disc by the recording means; and

background formatting means for formatting the optical disc by a formatting process performed as a background process so that another process is acceptable after a start of

the formatting process, the formatting process being performed so as to fill at least a predetermined part of a recording area of the optical disc by packets having a fixed length.

According to the above-mentioned invention, since the formatting process is performed as a background process so that another process can be accepted when the formatting operation is being performed, execution of a recording operation or a reproducing operation may be performed without waiting until the formatting process is completed.

In the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include end-of-process notifying means for notifying completion of the formatting process before the formatting process is completed. Accordingly, a host computer connected to the optical disc recording and reproducing apparatus can accept another process to be performed by the optical disc recording and reproducing apparatus.

Additionally, in the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include means for interrupting the formatting process when a request for recording user data is made, recording the user data on the optical disc and thereafter resuming the formatting process. Accordingly, a recording operation of data can be started at any time even when the formatting process is being performed.

Additionally, in the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include means for resuming the formatting process by excluding an area in which the user data has been recorded from among areas to be formatted when the packets having a fixed length are not yet recorded in the area in which the user data has been recorded. Accordingly, the user data recorded while the formatting process is being performed is not erased by overwriting with the packets having the fixed length when the formatting process is resumed.

In the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include means for interrupting the formatting process when a request for reproducing data recorded in a designated area is made, reproducing the data and thereafter resuming the formatting process. Accordingly, a reproducing operation can be started at any time even when the formatting process is being performed.

Additionally, in the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include means for outputting previously prepared information as a result of attempted reproduction of data recorded in the designated area when the packets having the fixed length are not yet recorded in the designated area by execution of the formatting process. Accordingly, a reproducing operation can be substitutionally performed when a reproducing operation cannot be performed since the area of which data is to be reproduced has not been formatted.

Additionally, in the optical disc recording and reproducing apparatus according to the present invention, the background formatting means may include means for prohibiting ejection of the optical disc when a request for ejecting the optical disc is made during an execution of the formatting process. Accordingly, the optical disc is not ejected when the formatting process is being performed. Thus, the optical disc is prevented from being incompletely formatted.

Additionally, there is provided according to another aspect of the present invention a formatting method for formatting a rewritable optical disc, data being recorded on the optical disc by using a fixed packet write method, the formatting method comprising the steps of:

starting a formatting process for the optical disc as a background process, the formatting process being performed so as to fill a recording area of the optical disc by packets having a fixed length;

enabling execution of another process while the formatting process is being performed; and

ending the formatting process after the recording area to be formatted has been filled by the packets having the fixed length.

According to the above-mentioned invention, since the formatting process is performed as a background process so that another process can be accepted when the formatting operation is being performed, execution of a recording operation or a reproducing operation may be performed without waiting until the formatting process is completed.

In the formatting method according to the present invention, the step of enabling may comprise the step of notifying of completion of the formatting process before the formatting process is completed.

Accordingly, a host computer connected to the optical disc recording and reproducing apparatus can accept another process to be performed by the optical disc recording and reproducing apparatus.

The formatting method according to the present invention may further comprise the steps of:

interrupting the formatting process when a request for recording user data is made;

recording the user data on said optical disc; and

resuming the formatting process after the user data has been recorded.

Accordingly, a recording operation of data can be started at any time even when the formatting process is being performed.

Additionally, in the formatting method according to the present invention, the step of resuming may include the step of excluding an area in which the user data has been recorded from among areas to be formatted when the packets having the fixed length are not yet recorded in the area in which the user data has been recorded.

Accordingly, the user data recorded while the formatting process is being performed is not erased by overwriting with the packets having the fixed length when the formatting process is resumed.

Additionally, the formatting method according to the present invention may further comprise the steps of:

interrupting the formatting process when a request for reproducing data recorded in a designated area is made;

reproducing the data in the designated area; and

resuming the formatting process after the data recorded in the designated area has been reproduced.

Accordingly, a reproducing operation of data can be started at any time even when the formatting process is being performed.

Additionally, in the formatting method according to the present invention, the step of reproducing may include the step of outputting previously prepared information as a result of attempted reproduction of the data recorded in the designated area when the packets having the fixed length are not yet recorded in the designated area by execution of the formatting process.

Accordingly, a reproducing operation can be substitutionally performed when a reproducing operation cannot be

performed since the area of which data is to be reproduced has not been formatted.

Additionally, the formatting method according to the present invention may further comprise the step of prohibiting ejection of the optical disc when a request for ejecting the optical disc is made during an execution of the formatting process.

Accordingly, the optical disc is not ejected when the formatting process is being performed. Thus, the optical disc is prevented from being incompletely formatted.

Additionally, there is provided according to another aspect of the present invention a processor readable medium storing program codes causing an optical disc recording and reproducing apparatus to perform the above-mentioned formatting methods.

Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an optical disc recording apparatus according to a first embodiment of the present invention;

FIG. 2 is an illustration for explaining a track and a format of a packet used in a fixed packet write method;

FIG. 3 is an illustration for explaining a format of a recording area of an optical disc which has been formatted by the optical disc recording and reproducing apparatus shown in FIG. 1;

FIG. 4 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1, the formatting process being performed as a background process;

FIG. 5 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1 when a request for recording data on the optical disc is made while the formatting process is being performed as a background process;

FIG. 6 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1 so as to prevent a recording area from being formatted, user data having been recorded in the recording area, while the formatting process is being performed as a background process;

FIG. 7 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1 when a request for reproducing data recorded on the optical disc is made while the formatting process is being performed as a background process;

FIG. 8 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1 when reproduction is performed on an unformatted recording area while the formatting operation is being performed as a background process; and

FIG. 9 is a flowchart of a formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1 when a request for ejecting the optical disc is made while the formatting process is being performed as a background process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description will now be given of a first embodiment of the present invention. FIG. 1 is a block diagram of an optical disc recording and reproducing apparatus according to the first embodiment of the present invention.

The optical disc recording and reproducing apparatus shown in FIG. 1 records information on an optical disc 1 such as a CD-RW by providing a train of pits spirally formed on the optical disc. The optical disc recording and reproducing apparatus reads the information on the optical disc 1 by information units referred to as user data blocks. The optical disc recording apparatus according to the present embodiment uses the above-mentioned fixed packet write method to record information on the optical disc 1.

As shown in FIG. 1, the optical disc recording and reproducing apparatus is provided with a spindle motor 2, an optical pickup 3 and a coarse adjustment motor 4. The spindle motor 2 rotates the optical disc 1. The optical pickup 3 has a semiconductor laser which projects a laser beam L onto a recording area of the optical disc 1. The coarse adjustment motor 4 moves the optical pickup 3 in a radial direction of the optical disc 1 in cooperation with a seek motor (not shown in the figure) provided in the optical pickup 3.

The optical disc recording and reproducing apparatus further includes a rotation control system 5, a coarse adjustment motor control system 6, an optical pickup control system 7 and a signal processing system 8. The rotation control system 5 controls operation of the spindle motor 2. The coarse adjustment motor control system 6 controls operation of the coarse adjustment motor 4. The optical pickup control system 7 controls operation of the optical pickup 3. The signal processing system 8 transmits information read by the optical pickup 3 and receives information to be recorded on the optical disc 1 by the optical pickup 3.

The optical disc recording apparatus is further provided with a controller 9 and an interface 10. The controller 9 controls the above-mentioned rotation control system 5, the coarse adjustment motor control system 6, the optical pickup control system 7 and the processing system 8. The interface 10 enables communication with an external host computer.

In the thus-constructed optical disc recording and reproducing apparatus, the optical pickup 3 is moved in the radial direction of the optical disc 1 while the optical disc 1 is rotated by the spindle motor 2 so as to record or read information by projecting the laser beam L from the semiconductor laser of the optical pickup 3 onto the recording area of the optical disc 1.

When the optical disc recording and reproducing apparatus shown in FIG. 1 records information, the controller 9 moves the optical pickup 3 in a radial direction of the optical disc 1 while the optical disc 1 is rotated. The laser beam L is projected from the optical pickup 3 onto the recording area of the optical disc 1 at a recording power level so as to record the information on the optical disc 1.

Additionally, when the optical disc recording and reproducing apparatus shown in FIG. 1 reproduces information recorded on the optical disc 1, the controller 9 moves the optical pickup 3 while the optical disc 1 is rotated. The laser beam L is projected from the optical pickup 3 onto the recording area of the optical disc 1 at a reproducing power level so as to read the information recorded on the optical disc 1. The reproduced information is transferred to the host computer via the interface 10.

In the optical disc recording and reproducing apparatus, the controller 9 controls a recording and reproducing operation of data in each track on the optical disc 1 according to the fixed packet write method. The controller 9 also controls a formatting operation for the optical disc 1 in a background

process. That is, the controller 9 serves as means for recording data on the rewritable optical disc 1 by the fixed packet write method and reproducing the recorded data. Additionally, the controller 9 sends a notification to notify of a completion of a formatting operation immediately after the formatting operation has started when the optical disc 1 is formatted. Thereafter, the controller 9 serves as background formatting means for formatting the optical disc 1 in a background process so as to record fixed packets in the entire recording area or a designated area of the optical disc 1.

Further, the controller 9 serves to interrupt the formatting operation when a request is made for recording user data during the formatting operation in the background process and restart the formatting operation after the user data has been recorded. Additionally, the controller 9 serves to resume the formatting operation, after the formatting operation is restarted while preventing the area in which the user data is recorded from being formatted.

Additionally, the controller 9 serves to interrupt the formatting operation when a request is made for reproducing user data recorded in a designated area during the formatting operation in the background process and restart the formatting operation after the user data recorded in the designated area has been reproduced. Further, the controller 9 serves to output predetermined information as a result of attempted reproduction of data in a designated area when the fixed packets are not yet recorded in the designated area by the formatting operation. Additionally, the controller 9 serves to prohibit the optical disc 1 from being ejected when a request is made to eject the optical disc 1 while the formatting operation is performed as the background process.

A description will now be given of the fixed packet write method used by the optical disc recording and reproducing apparatus shown in FIG. 1. A description will also be given of a format of a packet used in the fixed packet write method. FIG. 2 is an illustration for explaining a track and a format of a packet recorded on the optical disc 1 in a fixed packet write method.

According to the fixed packet write method, a plurality of tracks are formed in a recording area of the rewritable optical disc 1. Each of the tracks is divided into a plurality of packets each having the same number of user data blocks so that information is recorded for each individual packet at once.

Accordingly, in the fixed packet write method, each of the packets 12 in a single track 11 in the recording area of the optical disc 1 has the same packet length, and each of the packets 12 has the same number of the user data blocks.

The packet 12 includes a plurality of user data blocks 15 which can be reproduced. Additionally, the packet 12 includes five link blocks preceding the user data blocks 15. The five link blocks consist of one link block 13 and four run-in blocks 14. The packet 12 further includes two link blocks subsequent to the user data blocks 14. The two link blocks consist of two run-out blocks 16. These link blocks are used for connecting the packets 12 to each other when data is recorded in the user data blocks 15 of the packets 12 in the track 11 of the optical disc 1.

FIG. 3 is an illustration for explaining a format of the recording area of the optical disc which is formatted by the optical disc recording and reproducing apparatus shown in FIG. 1. As shown in FIG. 3, when the entire recording area or a designated area of the optical disc 1 is subjected to the formatting operation according to the fixed packet recording method, the entire recording area or the designated area is filled by the fixed packets.

A description will now be given of a formatting process performed as a background process in the optical disc recording and reproducing apparatus shown in FIG. 1. FIG. 4 is a flowchart of the formatting process performed by the optical disc recording and reproducing apparatus shown in FIG. 1.

Immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S1, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. Then, in step S2, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length. It is determined, in step S3, whether or not the area to be formatted is filled by the packets. If the area is not filled by the packets, the routine returns to step S2. If it is determined that the entire area is filled by the packets, the routine is ended.

In the above-mentioned formatting process, since the actual formatting operation is performed as a background process, recording or reproduction of data can be accepted by the host computer while the formatting operation is being progressed. Thus, the host computer does not wait for a long time to accept the recording or reproduction of data even when the formatting process is being performed.

A description will now be given of a case in which a request for recording data on the optical disc 1 is made during the above-mentioned formatting process. FIG. 5 is a flowchart of the formatting process performed as a background process when a request for recording is made during the formatting process.

Immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S11, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. Then, in step S12, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length. It is then determined, in step S13, whether or not a request for recording is sent from the host computer.

If it is determined, in step S13, that a request for recording is not sent from the host computer, the routine proceeds to step S15. On the other hand, if it is determined, in step S13, that a request for recording is sent from the host computer, the routine proceeds to step S14. In step S14, the formatting operation is temporarily stopped so as to record a user data packet. After the recording of the user data packet is completed, the routine proceeds to step S15.

In step S15, it is determined whether or not the area to be formatted is filled by the packets. If the area is not filled by the packets, the routine returns to step S12. If it is determined that the entire area to be formatted is filled by the packets, the routine is ended.

According to the above-mentioned formatting process, a recording operation can be performed any time the formatting operation is being progressed.

However, if the data is recorded in an unformatted area where the fixed packets are not yet recorded by the formatting process being performed, it is possible that fixed packets are overwritten on the recorded data after the formatting process is restarted. This results in erasure of the recorded data. In order to avoid such a problem, the optical disc recording and reproducing apparatus according to the present invention performs a formatting process shown in FIG. 6.

FIG. 6 is a flowchart of the formatting process for preventing a data recorded area from being formatted.

Immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S21, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. It is then determined, in step S22, whether or not a user data packet has been recorded. If it is determined that the user data packet has been recorded, the routine proceeds to step S24. On the other hand, if it is determined that the user data packet has not been recorded, the routine proceeds to step S23. In step S23, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length.

It is then determined, in step S24, whether or not a request for recording is sent from the host computer. If it is determined, in step S24, that a request for recording is not sent from the host computer, the routine proceeds to step S27. On the other hand, if it is determined, in step S24, that a request for recording is sent from the host computer, the routine proceeds to step S25 in which the formatting operation is temporarily stopped so as to record a user data packet. After the recording of the user data packet is completed, the routine proceeds to step S26. In step S26, the formatting operation is restarted and an address of the area in which the user data packet has been recorded is stored, and the routine proceeds to step S27.

In step S27, it is determined whether or not the area to be formatted is filled by the packets having a fixed length. If the area is not filled by the packets, the routine returns to step S22 so as to determine whether or not the user data packet has been recorded based on the address stored in step S26. If the user data packet has been recorded, the formatting process is continued while excluding the recorded area from being formatted. If the user data packet has not been recorded, the fixed packets are recorded. Accordingly, the process of steps S22 to S26 is repeated, and the routine is ended after the entire area to be formatted is filled by the fixed packets.

According to the above-mentioned formatting process, the fixed packets are not overwritten on the data which has been recorded while the formatting process is being performed. Thus, the recorded data is prevented from being undesirably erased after the formatting process is restarted.

A description will now be given of a case in which a request for reproduction of data is made while the formatting operation is being performed. FIG. 7 is a flowchart of a process when a request for reproduction of data is made while the formatting operation is being performed as a background process in the optical disc recording and reproducing apparatus shown in FIG. 1.

In the process shown in FIG. 7, immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S31, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. Then, in step S32, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length. It is then determined, in step S33, whether or not a request for reproducing data is sent from the host computer.

If it is determined, in step S33, that a request for reproducing data is not sent from the host computer, the routine proceeds to step S35. On the other hand, if it is determined, in step S33, that a request for reproducing data is sent from the host computer, the routine proceeds to step S34. In step S34, the formatting operation is temporarily stopped so as to reproduce data recorded on a designated area. After the reproduction of the data is completed, the routine proceeds to step S35.

In step S35, it is determined whether or not the area to be formatted is filled by the fixed packets. If the area is not filled by the fixed packets, the routine returns to step S32 so as to repeat the process of steps S32 to S34. If it is determined that the entire area to be formatted is filled by the fixed packets, the routine is ended.

According to the above-mentioned formatting process, a reproducing operation can be performed any time the formatting operation is being progressed.

If the fixed packets have not yet been recorded in the designated area in which the user data to be reproduced is recorded in the formatting operation performed as a background process, a reproducing operation cannot be performed since there is no packet to be reproduced. However, in order to have the user be unconscious of the formatting process being performed as a background process, it is better to reproduce data recorded in an unformatted area. Accordingly, in the optical disc recording and reproducing apparatus according to the present embodiment, data recorded in the unformatted area can be also reproduced while the formatting operation is being performed.

FIG. 8 is a flowchart of a process for performing a reproducing operation with respect to an unformatted area while the formatting operation is being performed as a background process.

In the process shown in FIG. 8, immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S41, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. Then, in step S42, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length. It is then determined, in step S43, whether or not a request for reproducing data is sent from the host computer.

If it is determined, in step S43, that a request for reproducing data is not sent from the host computer, the routine proceeds to step S47. On the other hand, if it is determined, in step S43, that a request for reproducing data is sent from the host computer, the routine proceeds to step S44. It is then determined, in step S44, whether or not a packet has been recorded in the area (designated area) from which data is requested to be reproduced.

If it is determined, in step S44, that the packet has been recorded, the routine proceeds to step S45 so as to reproduce the data from the recorded packet, and the routine proceeds to step S47. On the other hand, if it is determined that the packet has not been recorded, the routine proceeds to step S46. In step S46, pseudo-data such as ALL-0 (all zero data) which is previously stored in a memory is reproduced, and the routine proceeds to step S47.

As mentioned above, if data has not been recorded in the packet from which data is requested to be reproduced, the pseudo-data is reproduced and output so as to enable a reproducing operation as if the formatting process has ended.

In step S47, it is determined whether or not the area to be formatted is filled by the fixed packets. If the area is not filled by the fixed packets, the routine returns to step S42 so

as to repeat the process of steps S42 to S46. If it is determined that the entire area to be formatted is filled by the fixed packets, the routine is ended.

According to the above-mentioned formatting process, if data has not been recorded in the packet from which data is requested to be reproduced while the formatting operation is being performed, a reproducing operation can be performed by using the pseudo-data. Thus, the reproducing operation can be performed without the user being conscious of the formatting process being performed as a background process.

Additionally, when the fixed packets have not been recorded in the designated area by the formatting process, previously prepared information is output as a result of reproduction. Accordingly, a reproducing operation can be substitutionally performed even when a reproducing operation cannot be performed due to the fact that the formatting operation on the area subjected to the reproduction by interrupting the formatting process has not ended.

A description will now be given of a process when an instruction for ejection of the optical disc is provided while the formatting operation is being performed in the optical disc recording and reproducing apparatus according to the present embodiment.

If the optical disc 1 is ejected while the formatting process is being progressed, the formatting process cannot be continued. Additionally, the formatting of the ejected optical disc is incomplete and a recording and reproducing operation cannot be performed on the optical disc.

Accordingly, in the optical disc recording and reproducing apparatus according to the present embodiment, the optical disc 1 is prevented from being ejected when the formatting process is being performed.

FIG. 9 is a flowchart of a process when an instruction for ejecting an optical disc is provided during the formatting operation in the optical disc recording and reproducing apparatus according to the present embodiment.

In the process shown in FIG. 9, immediately after the formatting process for the optical disc 1 is started, the controller 9 outputs, in step S51, a message to a host computer so as to notify a user (the host computer) that the formatting process has been completed. Then, in step S52, an actual formatting operation is performed as a background process of the host computer. In the formatting operation, the entire area or a designated area of the optical disc 1 is filled by packets having a fixed length. It is then determined, in step S53, whether or not a request for ejecting the optical disc is sent from the host computer.

If it is determined, in step S53, that a request for ejecting the optical disc is not sent from the host computer, the routine proceeds to step S55. On the other hand, if it is determined, in step S53, that a request for ejecting the optical disc is sent from the host computer, the routine proceeds to step S54. In step S54, the formatting operation is continued without ejecting the optical disc 1 and an error message is output to the host computer, and the routine proceeds to step S55.

In step S55, it is determined whether or not the area to be formatted is filled by the fixed packets. If the area is not filled by the fixed packets, the routine returns to step S52 so as to repeat the process of steps S52 to S54. If it is determined that the entire area to be formatted is filled by the fixed packets, the routine is ended.

As mentioned above, the optical disc 1 is not ejected when the formatting operation is being performed so that a recording and reproducing operation is prevented from not being performed due to the incomplete formatting.

It should be noted that the above-mentioned formatting process may be performed in accordance with programs stored in a memory provided in the controller 9. The program data may be stored in a CD-ROM which is readable by the optical disc recording and reproducing apparatus, or may be supplied from the host computer via the interface 10.

The present invention is not limited to the specifically disclosed embodiments, and variations and modifications may be made without departing from the scope of the present invention.

The present application is based on Japanese priority application No.9-227921 filed on Aug. 25, 1997, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. An optical disc recording and reproducing apparatus, comprising:

recording means for recording data on a rewritable optical disc by using a fixed packet write method;

reproducing means for reproducing data recorded on said optical disc by said recording means; and

background formatting means for formatting said optical disc by a formatting process performed as a background process so that when at least one of a recording process and a reproducing process is requested, the formatting process is interrupted and the one of the recording process and reproducing process is performed and the formatting process is resumed after the one of the recording process and the reproducing process is ended, the formatting process being performed so as to fill at least a predetermined part of a recording area of said optical disc by packets having a fixed length.

2. An optical disc recording and reproducing apparatus, comprising:

recording means for recording data on a rewritable optical disc using a fixed packet write method;

reproducing means for reproducing data recorded on said optical disc by said recording means; and

background formatting means for formatting said optical disc by formatting process performed as a background process so that another process in acceptable after a start of the formatting process, the formatting process being performed so as to fill at least a predetermined part of a recording area of said optical disc by packets having a fixed length,

wherein said background formatting means includes end of process acknowledging means for notifying of completion of the formatting process before the formatting process is completed.

3. The optical disc recording and reproducing apparatus as claimed in claim 2, wherein said background formatting means includes means for interrupting the formatting process when a request for recording user data is made, recording the user data on said optical disc and thereafter resuming the formatting process.

4. The optical disc recording and reproducing apparatus as claimed in claim 3, wherein said background formatting means includes means for resuming the formatting process by excluding an area in which the user data has been recorded from among areas to be formatted when the packets having a fixed length are not yet recorded in the area in which the user data has been recorded.

5. The optical disc recording and reproducing apparatus as claimed in claim 2, wherein said background formatting

means include means for interrupting the formatting process when a request for reproducing data recorded in a designated area is made, reproducing the data and thereafter resuming the formatting process.

6. The optical disc recording and reproducing apparatus as claimed in claim 5, wherein said background formatting means includes means for outputting previously prepared information as a result of reproduction of data recorded in said designated area when the packets having a fixed length are not yet recorded in said designated area by execution of the formatting process.

7. The optical disc recording and reproducing apparatus as claimed in claim 2, wherein said background formatting means includes means for prohibiting ejection of said optical disc when a request for ejecting said optical disc is made during an execution of the formatting process.

8. A formatting method for formatting a rewritable optical disc, data being recorded on said optical disc by using a fixed packet write method, said formatting method comprising the steps of:

starting a formatting process for said optical disc as a background process, the formatting process being performed so as to fill a recording area of said optical disc by packets having a fixed length;

enabling execution of at least one of a recording process and a reproducing process by interrupting the formatting process and resuming the formatting process after the at least one of the recording process and the reproducing process is ended; and

ending the formatting process after the recording area to be formatted has been filled by the packets having the fixed length.

9. A formatting method for formatting a rewritable optical disc, data being recorded on said optical disc by using fixed packet write method, said formatting method comprising the steps of:

starting a formatting process for said optical disc as a background process, the formatting process being performed so as to fill a recording area of said optical disc by packets having a fixed length;

enabling execution of another process while the formatted process is being performed; and

ending the formatting process after the recording are to be formatted has been filled by the packets having the fixed length,

wherein the step of enabling comprises the step of notifying completion of the formatting process before the formatting process is completed.

10. The formatting method as claimed in claim 9, further comprising the steps of:

interrupting the formatting process when a request for recording user data is made;

recording the user data on said optical disc; and

resuming the formatting process after the user data has been recorded.

11. The formatting method as claimed in claim 10, wherein the step of resuming includes the step of excluding an area in which the user data has been recorded from among areas to be formatted when the packets having the fixed length are not yet recorded in the area in which the user data has been recorded.

12. The formatting method as claimed in claim 9, further comprising the steps of:

interrupting the formatting process when a request for reproducing data recorded in a designated area is made;

reproducing the data in said designated area; and

resuming the formatting process after the data in said designated area has been reproduced.

13. The formatting method as claimed in claim 12, wherein the step of reproducing includes the step of outputting previously prepared information as a result of reproduction of the data recorded in said designated area when the packets having a fixed length are not yet recorded in said designated area by execution of the formatting process.

14. The formatting method as claimed in claim 9, further comprising the step of prohibiting ejection of said optical disc when a request for ejecting said optical disc is made during an execution of the formatting process.

15. A processor readable medium for storing program code for causing an optical disc recording and reproducing apparatus to format a rewritable optical disc, data being recorded on said optical disc by using a fixed packet write method, comprising:

program code means for starting a formatting process for said optical disc as a background process, the formatting process being performed so as to fill a recording area of said optical disc by packets having a fixed length;

program code means for enabling execution of at least one of a recording process and a reproducing process by interrupting the formatting process and resuming the formatting process after the at least one of the recording process and the reproducing process is ended; and

program code means for ending the formatting process after the recording area to be formatted has been filled by the packets having the fixed length.

16. A processor readable medium for storing program code for causing an optical disc recording and reproducing apparatus to format a rewritable optical disc, data being recorded on said optical disc by using a fixed packet write method, comprising:

program code means for starting a formatting process for said optical disc as a background process, the formatting process being performed so as to fill a recording area of said optical disc by packets having a fixed length;

program code means for enabling execution of another process while the formatting process is being performed; and

program code means for ending the formatting process after the recording area to be formatted has been filled by packets having a fixed length,

wherein the program code means for enabling comprises program code means for notifying completion of the formatting process before the formatting process has been completed.

17. The processor readable medium as claimed in claim 16, further comprising:

program code means for interrupting the formatting process when a request for recording user data is made;

program code means for recording the user data on said optical disc; and

program code means for resuming the formatting process after the user data has been recorded.

18. The processor readable medium as claimed in claim 17, wherein the program code means for resuming includes program code means for excluding an area in which the user data has been recorded from among areas to be formatted when the packets having the fixed length are not yet recorded in the area in which the user data has been recorded.

19. The processor readable medium as claimed in claim 16, further comprising:

program code means for interrupting the formatting process when a request for reproducing data recorded in a designated area is made;

program code means for reproducing the data in said designated area; and

program code means for resuming the formatting process after the data has been recorded in said designated area.

20. The processor readable medium as claimed in claim 19, wherein the program code means for reproducing includes program code means for outputting previously prepared information as a result of reproduction of the data recorded in said designated area when the packets having a fixed length are not recorded in said designated area by execution of the formatting process.

21. The processor readable medium as claimed in claim 16, further comprising program code means for prohibiting ejection of said optical disc when a request for ejecting said optical disc is made during an execution of the formatting process.

* * * * *

EXHIBIT C

US006631109B2

(12) **United States Patent**
Nakamura

(10) Patent No.: **US 6,631,109 B2**
(45) Date of Patent: **Oct. 7, 2003**

(54) OPTICAL RECORDING METHOD AND APPARATUS, AND OPTICAL STORAGE MEDIUM

(75) Inventor: Yuki Nakamura, Kanagawa (JP)

(73) Assignee: Ricoh Company, Ltd., Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 307 days.

(21) Appl. No.: 09/795,436

(22) Filed: Mar. 1, 2001

(65) Prior Publication Data

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(30) Foreign Application Priority Data

Mar. 3, 2000 (JP) 2000-058399

(51) Int. Cl.[7] G11B 7/00; G11B 11/10
(52) U.S. Cl. 369/59.11; 369/53.3
(58) Field of Search 369/59.11, 53.3

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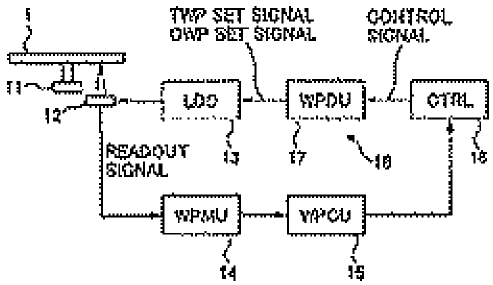
JP	63-266633	11/1988
WO	WO 98/36411	8/1998

Primary Examiner—Doris H. To
Assistant Examiner—Gautam R. Patel
(74) *Attorney, Agent, or Firm*—Dickstein Shapiro Morin & Oshinsky LLP

(57) ABSTRACT

In an optical recording method and apparatus of the present invention, a driving power is applied to a light source to control emission of a light beam to a recording layer of an optical storage medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock. A multi-pulse waveform of each mark portion of the driving power includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a duty ratio x=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe. The waveform is controlled, when a linear velocity of rotation of the medium is set in a range from 5 m/s to 28 m/s, such that the first pulse width t1 ranges 0.1T to 1T and the fourth pulse width t4 ranges 0.2T to 1.3T.

10 Claims, 5 Drawing Sheets



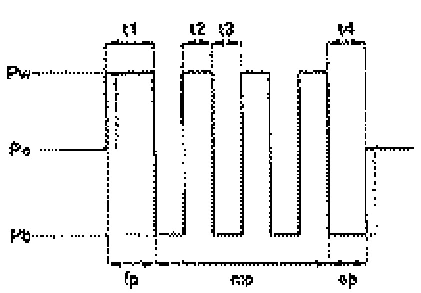


FIG.1

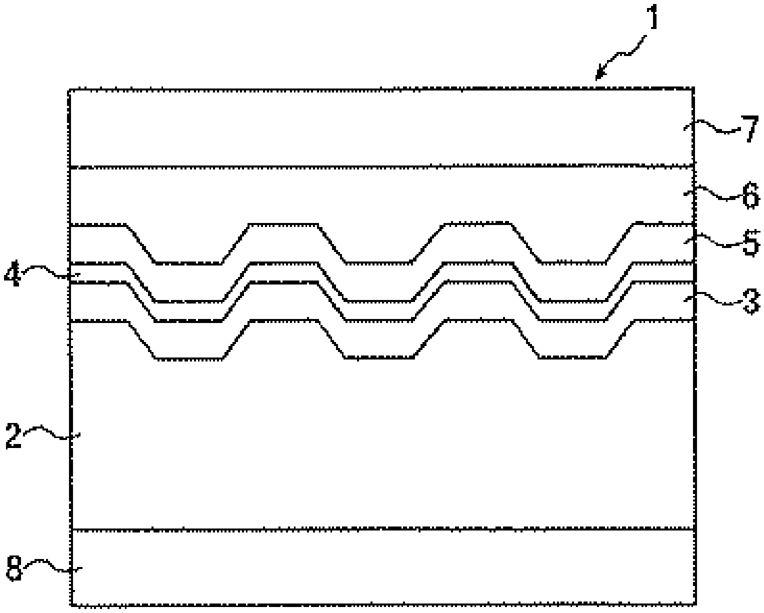
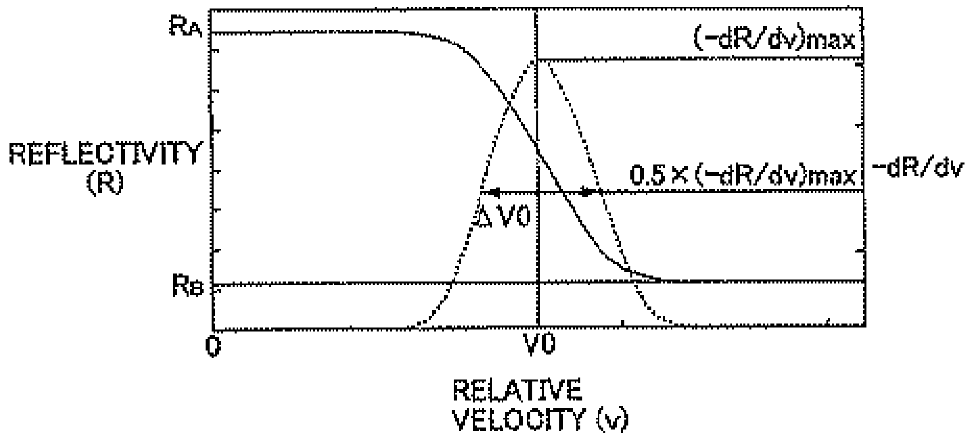
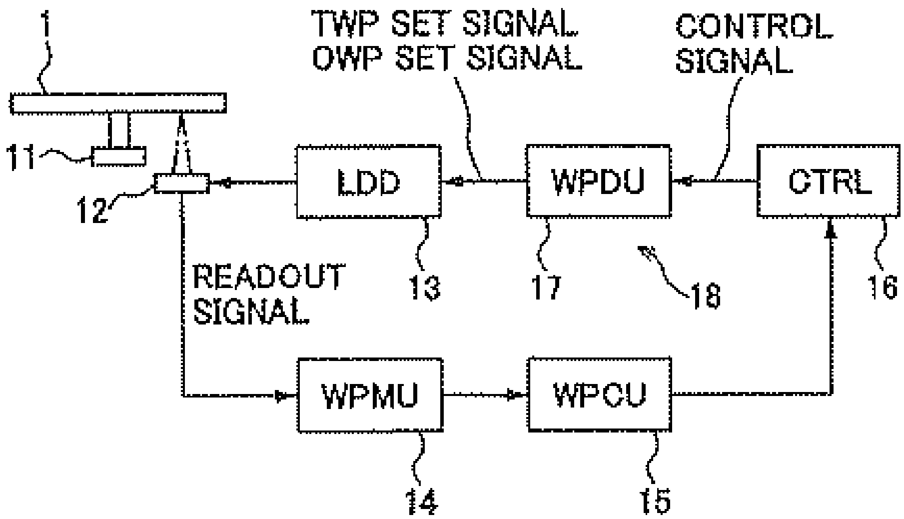


FIG.2



RA
(−dR/dv)max
REFLECTIVITY (R)
0.5×(−dR/dv)max
−dR/dv
ΔV0
RB
0
V0
RELATIVE VELOCITY (v)

FIG.3



1
TWP SET SIGNAL
OWP SET SIGNAL
CONTROL SIGNAL
11
12
LDD
WPDU
CTRL
READOUT SIGNAL
13
17
18
16
WPMU
WPCU
14
15

FIG.4A

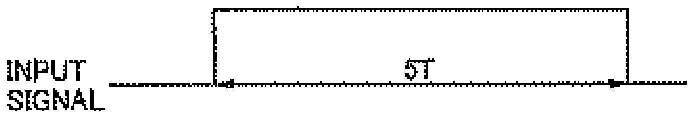


FIG.4B

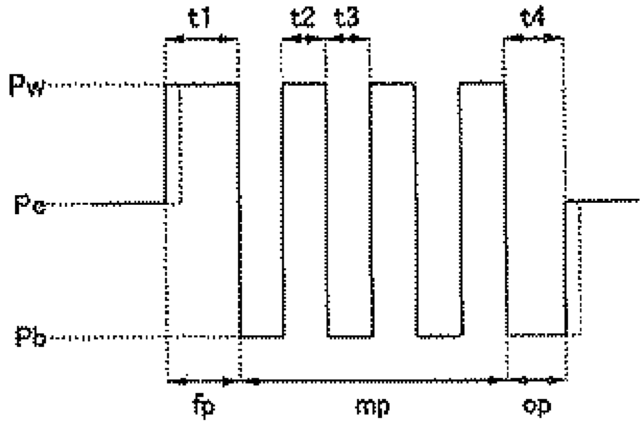
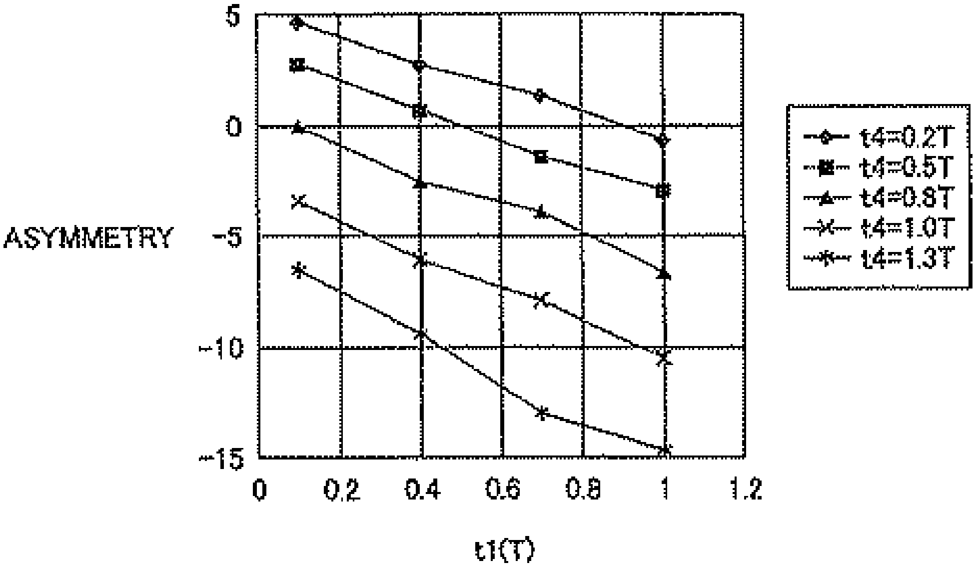


FIG.5



5
0
-5
-10
-15
ASYMMETRY
0
0.2
0.4
0.6
0.8
1
1.2
t1(T)
t4=0.2T
t4=0.5T
t4=0.8T
t4=1.0T
t4=1.3T

OPTICAL RECORDING METHOD AND APPARATUS, AND OPTICAL STORAGE MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical recording method and apparatus that records information onto an optical storage medium at a high speed by emitting a light beam to a recording layer of the storage medium. Further, the present invention relates to an optical storage medium that stores information recorded by using the optical recording method and apparatus.

2. Description of the Related Art

Recently, optical storage media, including CD-R (compact disk recordable), CD-RW (compact disk rewritable) and so on, become widespread. Each storage medium is provided for recording information thereon by focusing a light beam onto a recording layer of the medium and changing the phase of the recording layer material.

As disclosed in Japanese Laid-Open Patent Application No. 63-29336, an optical recording method that records information onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium is known. In the optical recording method of the above document, a light source driving waveform is applied to a light source to control emission of a light beam to the recording layer of the medium based on a write data modulation method. Moreover, there is known an optical recording method that determines an optimum light source driving waveform (including the write power and the write pulse width), which is applied to the light source, based on a readout signal of the recorded information derived from a reflection light beam from the optical disk.

Further, several optical recording methods have been proposed for improvement of the quality of the write signal recorded on a rewritable phase-change storage medium. For example, Japanese Laid-Open Patent Application No. 63-266632 discloses such improvement method. In the conventional method of the above document, a pulse width modulation (PWM) method is utilized for application of a multi-pulse light source driving waveform to the light source to control emission of a light beam from the light source to a rewritable phase-change optical disk having a recording layer with a large crystallization speed. The conventional method provides the driving waveform that is effective in recording a long amorphous mark on the recording layer of the optical disk.

In addition, Japanese Laid-Open Patent Application No. 63-266633 and U.S. Pat. No. 5,150,352 disclose an optical recording method which eliminates positional variations of a mark edge and improves the jitter characteristics of an optical disk by applying a driving waveform including a front-end portion or a tail-end portion having an increased pulse width or with an increased power level to the light source.

Further, the rewritable compact disk standards (the orange book, part III, ver. 2.0) provide the recommended specifications of 1× to 4× linear velocity recording of the rewritable recording media. The linear velocities 1× to 4× according to the standards (the orange book, part III, ver. 2.0) range from 1.2 m/s to 5.6 m/s. The recording speeds of the media in this range require a relatively long time to record information onto the media. There is an increasing demand for a reliable

CD-RW drive that is able to carry out error-free information recording with good write-erase characteristics at higher recording speeds. Preparations of high-speed specifications of 4× to 10× linear velocity recording for the rewritable compact disk standards are now under way. The linear velocities 4× to 10× according to the standards (the orange book, part III) range from 5 m/s to 28 m/s.

Accordingly, it is desirable to provide an optical recording method and apparatus that ensures good write/erase characteristics of the rewritable phase-change medium and retains the compatibility with the write-once storage medium when high-speed recording (equivalent to the 4× to 10× linear velocity recording) is performed. The conventional recording methods and devices of the above documents are not yet adequate to attain the goal.

SUMMARY OF THE INVENTION

It is a general object of the present invention to provide an optical recording method and apparatus in which the aforementioned problems are eliminated.

Another object of the present invention is to provide an optical recording method and apparatus that ensures good write/erase characteristics of the rewritable phase-change medium and retains the compatibility with the write-once storage medium when high-speed recording is performed.

Another object of the present invention is to provide an optical recording method and apparatus that provides increases of initial characteristics and overwrite performance of the rewritable phase-change medium.

Another object of the present invention is to provide an optical storage medium that stores information recorded by using the optical recording method and apparatus such that good write/erase characteristics of the rewritable phase-change medium are ensured and the compatibility with the write-once storage medium is retained when high-speed recording is performed.

The above-mentioned objects of the present invention are achieved by an optical recording method which records a sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, the method comprising the steps of: applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method; setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio $x=t2/(t2+t3)$, and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe; setting a linear velocity of rotation of the medium at a controlled speed; and controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

The above-mentioned objects of the present invention are achieved by an optical recording apparatus which records a

sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, the apparatus comprising: a light source driver unit which applies a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method; a write power determination unit which sets a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio x=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe; and a controller which sets a linear velocity of rotation of the medium at a controlled speed, wherein the controller causes the write power determination unit to control the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

The above-mentioned objects of the present invention are achieved by an optical storage medium which stores information recorded by using an optical recording method that records a sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, the optical recording method comprising the steps of: applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method; setting a multi-pulse waveform of each mark portion of the waveform that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio x=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe; setting a linear velocity of rotation of the medium at a controlled speed; and controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T, the optical storage medium comprising the sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion and second information indicative of the fourth pulse width t4 of the tail-end portion in the light source driving waveform.

In the optical recording method and apparatus of the present invention, the driving power is applied to the light source to control emission of a light beam to the recording layer of the optical storage medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of the period T of the write clock. The waveform of each mark portion of the driving power includes the front-end portion, the multi-pulse portion and the tail-end portion, the front-end portion having the first pulse width t1 with the write level Pw and starting from the erase level Pe, the multi-pulse portion including the write pulses each having the second pulse width t2 with the write level Pw and the third pulse width t3 with the base level Pb, the multi-pulse portion having the duty ratio x=t2/(t2+t3), and the tail-end portion having the fourth pulse width t4 with the base level Pb and ending at the erase level Pe. The waveform is controlled, when the linear velocity of rotation of the medium is set in a range from 5 m/s to 28 m/s, such that the first pulse width t1 ranges 0.1T to 1T and the fourth pulse width t4 ranges 0.2T to 1.3T. As the front-end edge and the tail-end edge of each mark (the amorphous phase) are accurately and definitely created on the recording layer of the rewritable phase-change medium when high-speed recording is performed, the optical recording method and apparatus of the present invention can ensure good write/erase characteristics of the rewritable phase-change medium and retain the compatibility with the write-once storage medium when high-speed recording is performed. The optical recording method and apparatus of the present invention are effective in increasing the initial characteristics and the overwrite performance of the rewritable phase-change medium.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the present invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings.

FIG. 1 is a cross-sectional diagram of one preferred embodiment of the optical storage medium of the invention.

FIG. 2 is a diagram for explaining a characteristic of storage medium's reflectivity with respect to relative velocity and a characteristic of the differential coefficient of the reflectivity with respect to relative velocity.

FIG. 3 is a block diagram of one preferred embodiment of the optical recording apparatus of the invention.

FIG. 4A and FIG. 4B are waveform diagrams for explaining a multi-pulse laser driving waveform used by the optical recording apparatus of FIG. 3.

FIG. 5 is a diagram for explaining the dependence of the write signal asymmetry on the front-end pulse width and the tail-end pulse width of the multi-pulse waveform.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A description will now be provided of preferred embodiments of the present invention with reference to the accompanying drawings.

FIG. 1 is a cross-sectional diagram of one preferred embodiment of the optical storage medium of the invention.

The optical storage medium of the present embodiment is a rewritable phase-change medium (CD-RW) in which a recording layer of a phase-change material is formed on a substrate. As shown in FIG. 1, in the storage medium 1 of this embodiment, a substrate 2, a lower protective layer 3, a recording layer 4, an upper protective layer 5, and a reflection/heat-radiation layer 6 are provided. The lower

protective layer 3, the recording layer 4, the upper protective layer 5 and the reflection/heat-radiation layer 6 are deposited, in this order, on the front surface of the substrate 2. Further, an overcoat layer 7 may be provided on the reflection/heat-radiation layer 6, and a hard-coat layer 8 may be provided on the back surface of the substrate 2.

In the medium 1 of the present embodiment, the substrate 2 is provided in order to support the recording layer 4. When a read/write laser beam emitted by a laser light source is incident to the substrate 2 of the storage medium 1, the substrate 2 must be transparent to the incident laser beam having a wavelength of the read/write laser beam used. A suitable transparent material of the substrate 2 is selected from among glass materials, ceramics materials and resin materials. Resin materials are more suitable for the substrate 2 because of the transparency and the ease of molding.

A suitable resin material of the substrate 2 may be selected from one of resin materials including polycarbonate resins, acrylic resins, epoxy resins, polystyrene resins, styrene-acrylonitrile copolymer resins, polyethylene resins, polypropylene resins, silicon-based resins, fluorine-based resins, acrylonitrile-butadiene-styrene (ABS) resins and urethane resins. In particular, polycarbonate resins or acrylic resins are selected as a more suitable material of the substrate 2, because of the ease of molding, the required optical characteristics and the cost effectiveness. A set of guide grooves may be provided on the transparent substrate 2.

In the storage medium 1 of the present embodiment, the lower and upper protective layers 3 and 5 are made of a dielectric material because of the required thermal and optical characteristics. A suitable material of the protective layers 3 and 5 may be selected from a single-component or mixture dielectric materials including oxides of SiO_2, SiO, ZnO, SnO_2, TiO_2, InO_2, Mg, ZrO_2, etc., nitrides of Si_3N_4, AlN, TiN, BN, ZrN, etc., sulphides of ZnS, In_2S_3, TaS_4, etc., carbides of SiC, TaC, B4C, WC, TiC, ZrC, etc., and diamond-state carbon. The lower and upper protective layers 3 and 5 are deposited by using physical vapor deposition, sputtering, ionplating, or chemical vapor deposition. Because of the productivity and the cost, sputtering is selected as the more suitable one for the formation of the lower and upper protective layers 3 and 5. An optimum thickness of the protective layers 3 and 5 may be determined in view of the required thermal and optical characteristics. Typically, the thickness of the protective layers 3 and 5 ranges from 10 nm to 5000 nm.

In the storage medium 1 of the present embodiment, the recording layer 4 is made of a phase-change material. A suitable phase-change material of the recording layer 4 may be selected from alloy-based phase-change materials including GeTe, GeTeSe, GeTeS, GeSeSb, GeAsSe, InTe, SeTe, SeAs, Ge—Te—(Sn, Au, Pd), GeTeSeSb, GeTeSb, AgInSbTe, etc. The composition of elemental substances in each phase-change material may be optimized in accordance with a linear velocity of rotation of the medium. A small amount of impurities, selected from substances including B, N, C, O, Si, P, S, Ge, Se, Al, Ti, Zr, V, Mn, Fe, Co, Ni, Cr, Cu, Zn, Sn, Pd, Pt, Au, etc., may be mixed with the phase-change material of the recording layer 4.

Specifically, the selection of AgInSbTe as the phase-change material of the recording layer 4 is more suitable because it provides definite boundaries between crystalline areas and non-crystalline (or amorphous) areas, which suits to a mark-edge recording technique (which will be described later) that is used by the optical recording method and apparatus of the present invention. A small amount of

impurities (for example, N) may be added to the phase-change material, which allows a margin of the linear velocity of the medium rotation to be increased.

In the storage medium 1 of the present embodiment, the composition of the phase-change material (AgInSbTe) of the recording layer 4 is represented by the formula $Ag_\alpha In_\beta Sb_\gamma Te_\delta$

$$0.1 \leq \alpha \leq 3.0$$

$$5.0 \leq \beta \leq 12.0$$

$$60.0 \leq \gamma \leq 72.0$$

$$22.0 \leq \delta \leq 30.0.$$

A desired thickness of the phase-change material of the recording layer 4 ranges from 13 nm to 17 nm. With the above composition and the above thickness of the phase-change material of the recording layer 4, the present embodiment can ensure good write/erase characteristics of the rewritable phase-change medium and retain the compatibility with the write-once storage medium even when high-speed recording is performed.

In the storage medium 1 of the present embodiment, the recording layer 4 is deposited on the substrate 2 by using physical vapor deposition, sputtering, ionplating, or chemical vapor deposition. Because of the productivity and the cost, sputtering is selected as the more suitable one for the formation of the recording layer 4.

Further, in the storage medium 1 of the present embodiment, the reflection/heat radiation layer 6 serves to reflect the read/write light beam and dissipate heat produced during recording. A suitable material of the reflection/heat radiation layer 6 may be selected from single-component metals including Ag, Au, Al, or mixture alloys including Ti, Si, Cr, Ta, Cu, Pd, C, etc. Preferably, the reflection/heat radiation layer 6 is made of an aluminum-based alloy because of the required thermal and optical characteristics and the productivity. A desired composition of the material of the reflection/heat radiation layer 6 and a desired thickness of the reflection/heat radiation layer 6 may be determined in view of the required thermal and optical characteristics.

In the storage medium 1 of the present embodiment, the overcoat layer 7 is made of a resin material containing, as the major component, an optical curing resin or an electron beam curing resin. Because of the ease of curing and the ease of film formation, a resin material containing, as the major component, a UV (ultraviolet ray) curing resin is more suitable for the material of the over-coat layer 7. The film formation of the over-coat layer 7 is performed by using a dipping method or a spin-coat method.

In order to conform to the high-speed specifications of 4x to 10x linear velocity recording for the expected rewritable compact disk standards, it is necessary that the optical storage medium 1 of the present embodiment be configured to meet the conditions related to the phase-change critical linear velocity (which will be called the velocity "vo").

Suppose that a measuring device (or a pickup) for measuring the phase-change critical linear velocity (the velocity "vo") of the medium meets the following conditions: the wavelength of a read/write laser beam emitted by the laser light source is 789 nm; and the numerical aperture (NA) of the objective lens is 0.49. Further, suppose that "v" indicates a relative velocity of the medium to the optical recording apparatus during the recording, "vwh" indicates the highest relative velocity of the medium during the recording, and "vwl" indicates the lowest relative velocity of the medium during the recording.

A measurement power "P_L" of the measuring device (or the pickup) used when measuring the velocity "vo" of the medium is defined by the formula: $P_L=0.75\ P_{OH}$ where "P_{OH}" indicates an optimum recording power when the linear velocity "v" of the medium 1 is set at the highest linear velocity "vwh".

The measurement of the velocity "vo" is performed when the medium 1 is moved to the pickup at the relative velocity "v" and the pickup emits a write laser beam to the medium from the laser light source at the measurement power "P_L". At this time, a pulsed light source emission waveform, which is ordinarily used for the recording of conventional phase-change media, is not used for the emission of the laser beam. A direct-current (DC) driving waveform is used for the emission of the write laser beam, and a reflectivity of the recorded portion of the medium is detected based on a reflection beam from the medium by a reproducing part of the optical recording apparatus. The reflectivity obtained at this time is indicated by a variable R(v) with respect to the relative velocity "v". Suppose that the wavelength of the read laser beam is set at 789 nm.

FIG. 2 shows a characteristic of the reflectivity "R" of the medium 1 of the present embodiment with respect to the relative velocity "v" and a characteristic of the differential coefficient "−dR/dv" of the reflectivity with respect to relative velocity "v".

As shown in FIG. 2, as the relative velocity "v" increases, the reflectivity "R" decreases from an initial saturation point "R_A". When a certain point of the relative velocity "v" is reached, the decrease of the reflectivity "R" is stopped at a secondary saturation point "R_B". Conversely, as the relative velocity "v" decreases, the reflectivity "R" increases from the secondary saturation point R_B, and when a certain point of the relative velocity "v" is reached, the increase of the reflectivity "R" is stopped at the initial saturation point R_A.

As is apparent from FIG. 2, the phase-change critical relative velocity "vo" of the medium is defined by a value of the relative velocity "v" when the differential coefficient "−dR/dv" of the reflectivity is the maximum "(−dR/dv)max" (the peak point). A margin "Δvo" of the velocity "vo" is defined by an effective range of the linear velocity "v" when the differential coefficient "−dR/dv" of the reflectivity decays to half the maximum "(−dR/dv)max".

In the storage medium 1 of the present embodiment, the phase-change material of the recording layer is selected such that it satisfies the following conditions:

$$vo \geq 0.7vwh$$

where "vo" is the phase-change critical linear velocity, and "vwh" is the highest linear velocity.

It has been confirmed from experiments that, when the optical storage medium 1 of the present embodiment is configured to meet the above conditions (in other words, the velocity "vo" of the medium 1 is set to satisfy the above conditions), the medium 1 provides good write/erase characteristics as well as improved overwrite performances when the recording is performed at the highest linear velocity "vwh".

On the other hand, when the medium 1 does not meet the above conditions, it provides poor write/erase characteristics as well as undesired overwrite performances when the recording is performed at the highest linear velocity "vwh". The primary reason is that it is difficult that such medium 1 returns the state of a mark on the medium with the reflectivity being at the secondary saturation point R_B back to the state of a space on the medium with the reflectivity being at the initial saturation point R_A.

Further, in the storage medium 1 of the present embodiment, it is preferred that the phase-change material of the recording layer is selected such that it satisfies the following conditions:

$$vo \leq 2.0vwl$$

where "vo" is the phase-change critical linear velocity, and "vwl" is the lowest linear velocity.

It has been confirmed from experiments that, when the optical storage medium 1 of the present embodiment is configured to meet the above conditions (in other words, the velocity "vo" of the medium 1 is set to satisfy the above conditions), the medium 1 provides good mark-formation characteristics as well as improved overwrite performances when the recording is performed at the lowest linear velocity "vwl".

The margin "Δvo" of the medium 1 indicates the tendency of deterioration of the recording signal at the highest linear velocity "vwh". In the storage medium 1 of the present embodiment, it is preferred that the phase-change material of the recording layer is selected such that it satisfies the following conditions:

$$\Delta vo/vo \leq 0.4$$

where "vo" is the phase-change critical linear velocity, and "Δvo" is the margin of the velocity "vo".

It has been confirmed from experiments that, when the optical storage medium 1 of the present embodiment is configured to meet the above conditions (in other words, the velocity "vo" of the medium 1 is set to satisfy the above conditions), the medium 1 provides improved stability of write/erase characteristics when the recording is performed at the highest linear velocity "vwh".

Further, in the storage medium 1 of the present embodiment, it is preferred that the phase-change material of the recording layer is selected such that it satisfies the following conditions:

$$0.1 \leq R_B/R_A \leq 0.6$$

where "R_A" is the initial saturation point of the medium, and "R_B" is the secondary saturation point of the medium.

It has been confirmed from experiments that, when the optical storage medium 1 of the present embodiment is configured to meet the above conditions, the medium 1 provides a good mark/space contrast when the recording is performed.

Further, in the storage medium 1 of the present embodiment, it is preferred that the phase-change material of the recording layer is selected such that it satisfies the following conditions:

$$vwh/vwl \leq 2.5$$

where "vwh" is the highest linear velocity of the medium during the recording, and "vwl" is the lowest linear velocity of the medium during the recording.

It has been confirmed from experiments that, when the optical storage medium 1 of the present embodiment is configured to meet the above conditions, it makes it possible to perform the constant angular velocity (CAV) recording of a 120-mm diameter optical disk (currently the dominating one) in the recording linear velocities corresponding to the disk recording areas ranging from 46.5 mm diameter to 116 mm diameter.

FIG. 3 shows one preferred embodiment of the optical recording apparatus of the invention. The optical recording apparatus of the present embodiment is configured to conform to the high-speed specifications of 4x to 10x linear velocity recording for the expected rewritable compact disk standards.

As shown in FIG. 3, in the optical recording apparatus of the present embodiment, the optical storage medium 1 is held on and rotated by a spindle motor 11. A controller (CTRL)16 controls the spindle motor 11 so that the linear velocity of rotation of the medium 1 is set at a controlled speed. A pickup 12 having a laser light source (for example, a laser diode) and optical systems (for example, a focusing lens and an objective lens) is provided to focus a laser beam, emitted by the light source, onto the recording layer of the medium 1 and change the phase of the recording material of the layer. The pickup 12 includes a photodetector which detects a reflection laser beam reflected from the recording layer of the medium 1 and outputs a readout signal based on the reflection laser beam.

In the optical recording apparatus of FIG. 3, a laser diode driver (LDD) 13 is provided to apply a laser driving power to the light source of the pickup 12 to control the emission of a laser beam to the recording layer of the medium 1. When recording of the medium 1 is performed, the LDD 13 applies the driving power to the light source of the pickup 12, and the light source emits the laser beam to the recording layer of the medium 1 to change the phase of the recording material of the layer. When reproducing of the medium 1 is performed, the photodetector of the pickup 12 detects the reflection laser beam reflected from the recording layer of the medium 1 and outputs the readout signal based on the reflection laser beam. In the optical recording apparatus of the present embodiment, the readout signal output by the photodetector of the pickup 12 is used to carry out the reproducing of the recorded information, the tracking servo control and the focusing servo control.

In the optical recording apparatus of FIG. 3, during the recording of the medium 1, the readout signal output by the pickup 12 is supplied to a write power monitoring unit (WPMU) 14. The write power monitoring unit 14 monitors the readout signal received from the pickup 12. A write power calculating unit (WPCU) 15 is provided to calculate the power (or the amplitude) of the readout signal and outputs the calculation result (the calculated power) to the controller 16. The controller 16 has a CPU (central processing unit), which controls the elements of the optical recording apparatus of the present embodiment. As described above, the controller 16 controls the rotating speed of the spindle motor 12 so that the linear velocity of rotation of the medium 1 is set at a controlled speed.

In the optical recording apparatus of FIG. 3, a write power determination unit (WPDU) 17 is provided to set a multi-pulse waveform of the laser driving power that is applied to the pickup 12. The controller 16 outputs a control signal to the WPDU 17 based on the feedback result (or the calculated power) from the MPCU 15, so that the WPDU 17 outputs a selected one of a test writing power (TWP) set signal and an optimum writing power (OWP) set signal to the LDD 13.

In the optical recording apparatus of the present embodiment, the pickup 12, the LDD 13, the WPDU 17 and the controller 16 form an optical information recording means 18. The optical information recording means 18 carries out a mark-edge recording process for the storage medium 1 wherein a sequence of data blocks (also called the write information), which corresponds to a sequence of mark and space portions of the driving power, are recorded onto the recording layer of the medium 1, each of the mark portions having a pulse width corresponding to a multiple of a period (T) of a write clock based on a PWM (pulse width modulation) method. In a case of the rewritable phase-change medium (CD-RW), the optical information recording means 18 converts each data block in the write information into a power level and a pulse width in the driving waveform by using an EFM (eight to fourteen modulation) process or another improved modulation technique based on the period T of the write clock.

In the optical recording apparatus of the present embodiment, the WPDU 17 sets a multi-pulse laser waveform of the driving power in order to control the emission of a laser beam by the laser light source of the pickup 12 to the recording layer of the medium 1 (CDRW). FIG. 4A and FIG. 4B are waveform diagrams for explaining the multi-pulse laser driving waveform used by the optical recording apparatus of FIG. 3.

FIG. 4A shows the waveform of a 5T input signal where "T" indicates the period of the write clock in the optical recording apparatus of FIG. 3. The "5T" input signal means that this pulsed signal has a pulse width that is 5 times the period T of the write clock. In the example of FIG. 4A, the high-level signal portion represents "1" of the write information and corresponds a mark on the recording layer of the medium 1, and the low-level signal portions represent "0" of the write information and correspond to spaces on the recording layer of the medium 1.

FIG. 4B shows an example of the multi-pulse laser driving waveform that is set by the WPDU 17 of the present embodiment in response to the input signal of FIG. 4A.

As shown in FIG. 4A and FIG. 4B, the multi-pulse waveform, supplied from the WPDU 17 to the LDD 13, includes a front-end portion "fp", a multi-pulse portion "mp" and a tail-end portion "op". The front-end portion "fp" has a first pulse width "t1" with a high-power write level "Pw" and starts from a middle-power erase level "Pe". The multi-pulse portion "mp" includes a sequence of write pulses each having a second pulse width "t2" with the write level Pw and a third pulse width "t3" with a low-power base level "Pb". Suppose that the conditions: Pb<Pe<Pw are met. The multi-pulse portion "mp" has a given duty ratio $x=t2/(t2+t3)$. The tail-end portion "op" has a fourth pulse width "t4" with the base level Pb and ends at the erase level Pe.

Generally, when one of the mark portions of the driving power is supplied to the light source of the pickup 12, a non-crystalline area (the amorphous phase) that represents "1" of the write information is formed as a mark on the recording layer of the medium 1 by the emission of a laser beam from the light source to the medium 1. The formation of the amorphous phase of the recording material on the recording layer of the medium 1 requires heating of the recording layer to an increased temperature above the melting point of the recording material and cooling of the recording layer for an adequate time after the heating.

In the waveform of FIG. 4B, the front-end portion "fp", which has the first pulse width t1 with the high-power write level Pw, provides the recording layer of the medium 1 with the energy needed to heat it to the increased temperature above the melting point. The multi-pulse portion "mp", which includes the sequence of write pulses each having the second pulse width t2 with the write level Pw and the third pulse width t3 with the base level Pb, provides the recording layer with the energy needed to form the mark thereon. Hence, if the first pulse width t1 is set at an optimum value and the waveform of the present embodiment is applied, a front-end edge of the mark can be accurately and definitely formed on the recording layer of the medium 1.

Further, in the waveform of FIG. 4B, the tail-end portion "op", which has the fourth pulse width t4 with the low-power base level Pb, serves to cool the recording layer of the medium 1 for an adequate time after the heating. Hence, if the fourth pulse width t4 is set at an optimum value and the waveform of the present embodiment is applied, a tail-end edge of the mark can be accurately and definitely formed on the recording layer of the medium 1.

It is necessary to take into consideration the above points, in order to provide good write/erase characteristics of the rewritable phase-change media when high-speed recording (equivalent to the 4x to 10x linear velocity recording) is performed. To attain the objective of the present invention, the optical recording apparatus of the present embodiment is configured such that the controller 16 causes the write power determination unit (WPDU) 17 to control the multi-pulse waveform of FIG. 4B when the linear velocity of rotation of the medium 1 is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width "t1" of the front-end portion "fp" ranges 0.1T to 1T and the fourth pulse width "t4" of the tail-end portion "op" ranges 0.2T to 1.3T. Optimum values of the first pulse width t1 and the fourth pulse width t4 vary depending on the recording material of the recording layer of the medium 1.

Experiments have been performed to ascertain the advantages of the optical recording apparatus of the present embodiment that is configured as described above. FIG. 5 shows the dependence of the write signal asymmetry on the front-end pulse width "t1" and the tail-end pulse width "t4" of the multi-pulse waveform.

In the present embodiment, the controller 16 causes the WPDU 17 to control the waveform when the linear velocity of rotation of the medium 1 is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T. In order to examine the performances of high-speed recording, the experiments are performed under the following conditions.

A CD-RW disk that is provided in conformity with the above-described embodiment of the optical storage medium of the invention is used for the experiments, and the CD-RW disk is called the medium 1. The wavelength of a laser beam emitted by the laser light source of the pickup 12 in the optical recording apparatus is 780 nm. The numerical aperture (NA) of the objective lens of the pickup 12 is set at 0.5. A high-speed recording of the medium 1 is performed at 9.6 m/s linear speed (which is equivalent to 8x linear velocity of the rewritable compact disk standards).

As shown in FIG. 5, when performing the experiments, the first pulse width "t1" of the front-end portion "fp" of the multi-pulse waveform is sequentially changed to one among 0.1T, 0.4T, 0.7T and 1.0T, and, at the same time, the fourth pulse width "t4" of the tail-end portion "op" of the multi-pulse waveform is changed to one among 0.2T, 0.5T, 0.8T, 1.0T and 1.3T with respect to each of the respective first pulse width values. By performing the experiments, the dependence of the write signal asymmetry on the front-end pulse width "t1" and the tail-end pulse width "t4" of the multi-pulse waveform is evaluated. FIG. 5 shows such results of the evaluations. Generally, the write signal asymmetry indicates the degree of asymmetry of mark length and space length, and it is represented by a normalized value obtained by dividing a difference between the average level of the radio-frequency (RF) signal amplitude of the longest mark and the average level of the RF signal amplitude of the shortest mark by the RF signal amplitude of the longest mark.

The specifications of the rewritable compact disk standards provide the requirements: $-15 \leq \text{asymmetry} \leq 5$. As is apparent from the characteristics of FIG. 5, in order to meet the requirements, it is necessary that the front-end pulse width "t1" of the multi-pulse waveform ranges from 0.1T to 1.0T and the tail-end pulse width "t4" of the multi-pulse waveform ranges from 0.2T to 1.3T.

In another preferred embodiment of the optical recording method and apparatus of the invention, the optical storage medium 1 is prepared, in advance, to contain a sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion "fp" and second information indicative of the fourth pulse width t4 of the tail-end portion "op" in the multi-pulse waveform. In the present embodiment, optimum values of the first pulse width t1 and the fourth pulse width t4 that are suited to a specific phase-change material of each individual medium 1 are predetermined. And, wobbling grooves or the like, carrying both the first information and the second information are formed on the medium 1.

In the optical recording method and apparatus of the present embodiment, prior to a start of the recording of the medium 1, a test writing process is performed in which test data blocks are recorded onto a test-write region (for example, a power calibration area PCA) of the medium 1 and a readout signal is detected from the test-write region of the medium 1, the readout signal indicative of the first information and the second information related to the test data blocks. Further, optimum values of the first pulse width t1 and the fourth pulse width t4 are calculated based on the first information and the second information indicated by the readout signal. In the present embodiment, the multi-pulse waveform is controlled based on the optimum values of the first pulse width t1 and the fourth pulse width t4.

According to the above-described embodiment, the optimum values of the first pulse width t1 and the fourth pulse width t4 in the multi-pulse waveform can be suitably determined. As the recording of the medium 1 can be performed in the optimum conditions, the optical recording method and apparatus of the present embodiment are effective in preventing the occurrence of a read error after the recording of the medium 1 is performed, due to deterioration of the write signal quality of the medium 1.

Further, for the sake of convenience of the users, it is preferred to make commercially available the optical storage medium 1 that is formatted, in advance, to contain the first information indicative of the first pulse width t1 of the front-end portion "fp" and the second information indicative of the fourth pulse width t4 of the tail-end portion "op" in the multi-pulse waveform. The formatted medium 1 of the present embodiment provides the users with the ease-to-use feature as well as good write/erase characteristics of the rewritable phase-change medium when the high-speed recording is performed.

The present invention is not limited to the above-described embodiments, and variations and modifications may be made without departing from the scope of the present invention.

Further, the present invention is based on Japanese priority application No. 2000-058399, filed on Mar. 3, 2000, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. An optical recording method which records a sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the

medium and changing a phase of a recording material of the recording layer, comprising the steps of:

applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method;

setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio z=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe;

setting a linear velocity of rotation of the medium at a controlled speed; and

controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

2. The optical recording method according to claim 1, wherein the optical storage medium contains the sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion and second information indicative of the fourth pulse width t4 of the tail-end portion in the waveform.

3. The optical recording method according to claim 2, further comprising the steps of:

performing a test writing process in which test data blocks are recorded onto a test-write region of the medium and a readout signal is detected from the test-write region of the medium, the readout signal indicative of the first information and the second information related to the test data blocks; and

calculating optimum values of the first pulse width t1 and the fourth pulse width t4 based on the first information and the second information indicated by the readout signal, wherein, in said controlling step, the waveform is controlled based on the optimum values of the first pulse width t1 and the fourth pulse width t4.

4. An optical recording method which records a sequence of data blocks onto a recording layer of a rewritable optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, comprising the steps of:

applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark portion having a pulse width that corresponds to a multiple of a period T of a write clock based on a pulse width modulation method;

setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio z=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe;

setting a linear velocity of rotation of the medium at a controlled speed; and

controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

5. An optical recording apparatus for recording a sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, comprising:

a light source driver unit applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method;

a write power determination unit setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio z=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe; and

a controller setting a linear velocity of rotation of the medium at a controlled speed,

wherein the controller causes the write power determination unit to control the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

6. The optical recording apparatus according to claim 5, wherein the optical storage medium contains the sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion and second information indicative of the fourth pulse width t4 of the tail-end portion in the waveform.

7. The optical recording apparatus according to claim 6, wherein the controller performs a test writing process in which test data blocks are recorded onto a test-write region of the medium and a readout signal is detected from the test-write region of the medium, the readout signal indicative of the first information and the second information related to the test data blocks, wherein the controller causes a write power calculating unit to calculate optimum values of the first pulse width t1 and the fourth pulse width t4 based on the first information and the second information indicated by the readout signal.

8. An optical recording apparatus for recording a sequence of data blocks onto a recording layer of a rewritable optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, comprising:

a light source driver unit applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a pulse width modulation method;

a write power determination unit setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio y=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe; and

a controller setting a linear velocity of rotation of the medium at a controlled speed,

wherein the controller causes the write power determination unit to control the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T.

9. An optical storage medium which stores information recorded by using an optical recording method that records a sequence of data blocks onto a recording layer of an optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, the optical recording method comprising the steps of:

applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark potion having a pulse width that corresponds to a multiple of a period T of a write clock based on a write data modulation method;

setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio y=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe;

setting a linear velocity of rotation of the medium at a controlled speed; and

controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T,

said optical storage medium comprising the sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion and second information indicative of the fourth pulse width t4 of the tail-end portion in the waveform.

10. An optical storage medium which stores information recorded by using an optical recording method that records a sequence of data blocks onto a recording layer of a rewritable optical recording medium by emitting light to the recording layer of the medium and changing a phase of a recording material of the recording layer, the optical recording method comprising the steps of:

applying a light source driving power to a light source to control emission of a light beam to the recording layer of the medium, the driving power including a sequence of mark and space portions, each mark portion having a pulse width that corresponds to a multiple of a period T of a write clock based on a pulse width modulation method;

setting a multi-pulse waveform of each mark portion of the driving power that includes a front-end portion, a multi-pulse portion and a tail-end portion, the front-end portion having a first pulse width t1 with a high-power write level Pw and starting from a middle-power erase level Pe, the multi-pulse portion including a sequence of write pulses each having a second pulse width t2 with the write level Pw and a third pulse width t3 with a low-power base level Pb, the multi-pulse portion having a given duty ratio y=t2/(t2+t3), and the tail-end portion having a fourth pulse width t4 with the base level Pb and ending at the erase level Pe;

setting a linear velocity of rotation of the medium at a controlled speed; and

controlling the waveform when the linear velocity of rotation of the medium is set in a high-speed range from 5 m/s to 28 m/s, such that the first pulse width t1 of the front-end portion ranges 0.1T to 1T and the fourth pulse width t4 of the tail-end portion ranges 0.2T to 1.3T,

said optical storage medium comprising the sequence of data blocks recorded on the recording layer, each data block including first information indicative of the first pulse width t1 of the front-end portion and second information indicative of the fourth pulse width t4 of the tail-end portion in the light source driving waveform.

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EXHIBIT D

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(12) **United States Patent**
Yamamoto

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(54) OPTICAL DISC APPARATUS

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(58) **Field of Search** 369/47.33, 47.34, 369/47.37, 47.51

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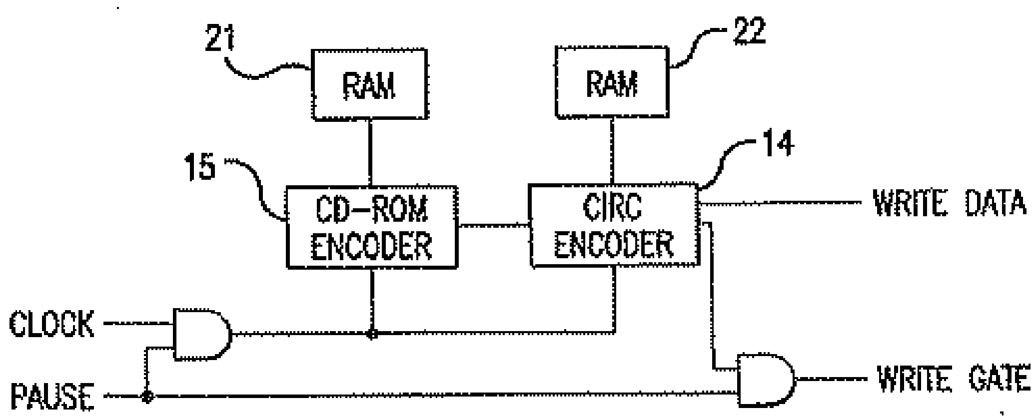
(57) **ABSTRACT**

An optical disc apparatus includes a pause circuit for pausing data encoders upon receiving a pause signal so that a write operation may be paused without writing dummy data, thereby maintaining data succession. The optical disc apparatus also includes a circuit for accurately determining a write start location by referring to previously written data. A processor generates a pause signal when the amount of data in the optical drive apparatus data buffer is low, and removes the pause signal when additional data from a host is received. The processor may also automatically reduce the write speed of the optical disc apparatus upon a pause condition, thereby preventing the necessity for excessive pausing.

3 Claims, 9 Drawing Sheets



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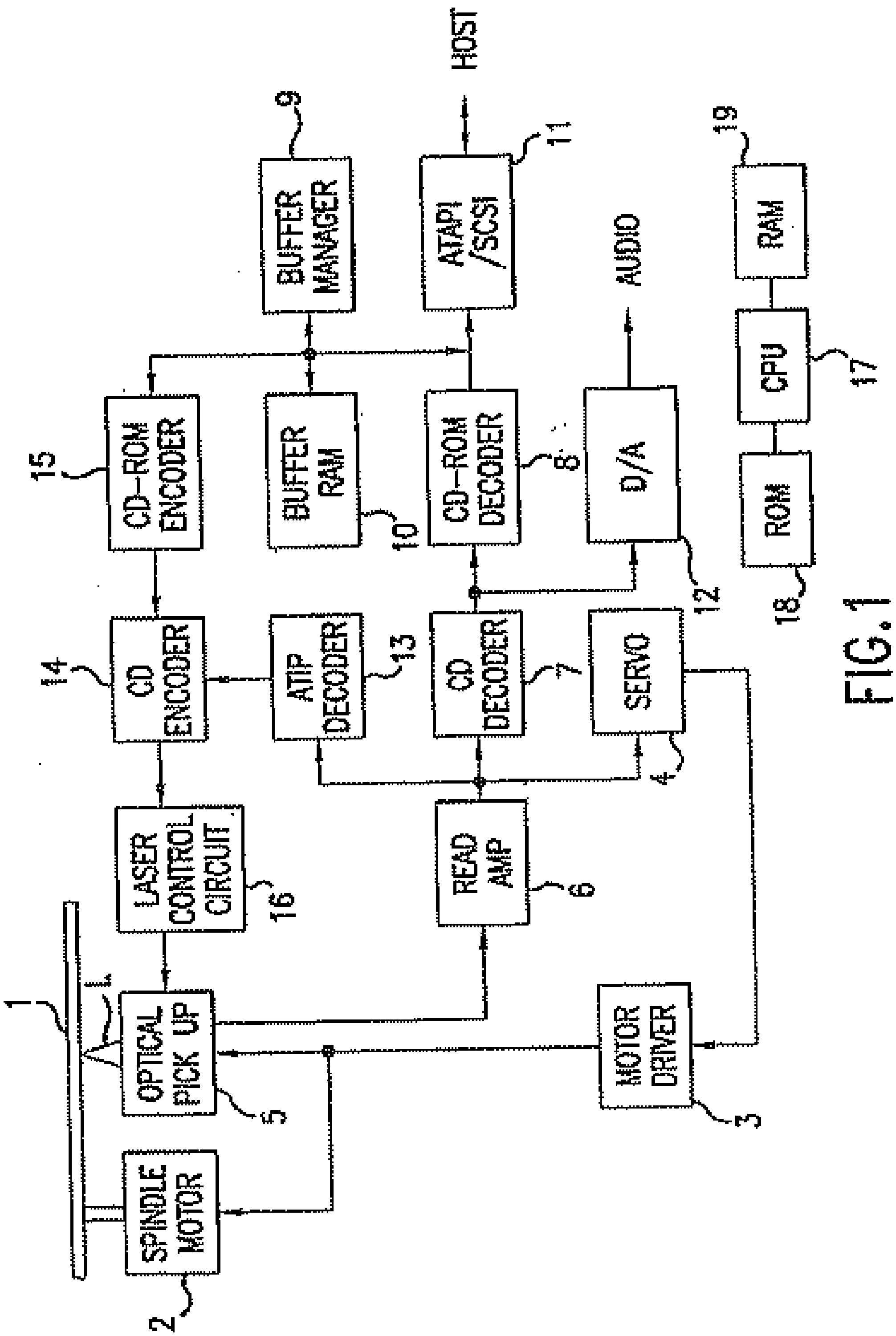
HOST
BUFFER MANAGER
ATAPI /SCSI
AUDIO
RAM
CPU
ROM
CD-ROM ENCODER
BUFFER RAM
CD-ROM DECODER
D/A
CD ENCODER
ATIP DECODER
CD DECODER
SERVO
LASER CONTROL CIRCUIT
READ AMP
OPTICAL PICK UP
MOTOR DRIVER
SPINDLE MOTOR
L
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

FIG. 1

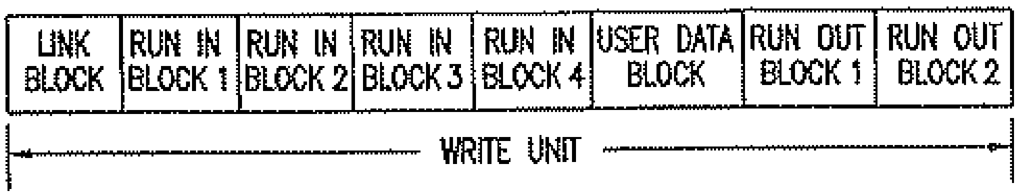
LINK BLOCK
RUN IN BLOCK 1
RUN IN BLOCK 2
RUN IN BLOCK 3
RUN IN BLOCK 4
USER DATA BLOCK
RUN OUT BLOCK 1
RUN OUT BLOCK 2
WRITE UNIT

FIG.2

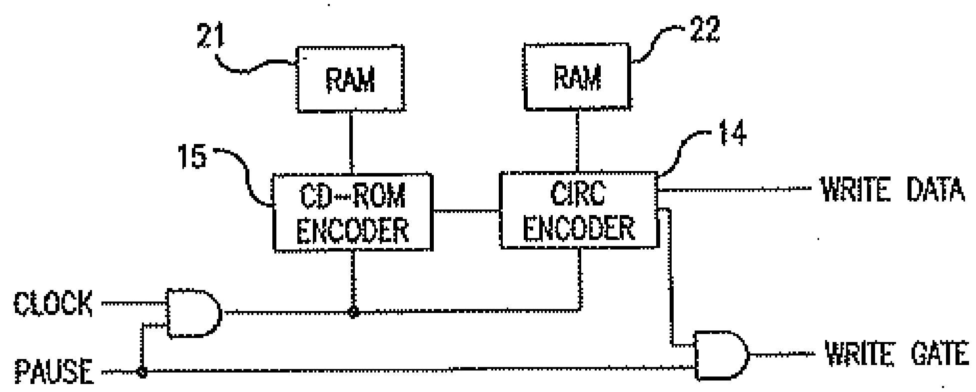
21
RAM
22
RAM
15
CD-ROM ENCODER
14
CIRC ENCODER
WRITE DATA
CLOCK
PAUSE
WRITE GATE

FIG.4

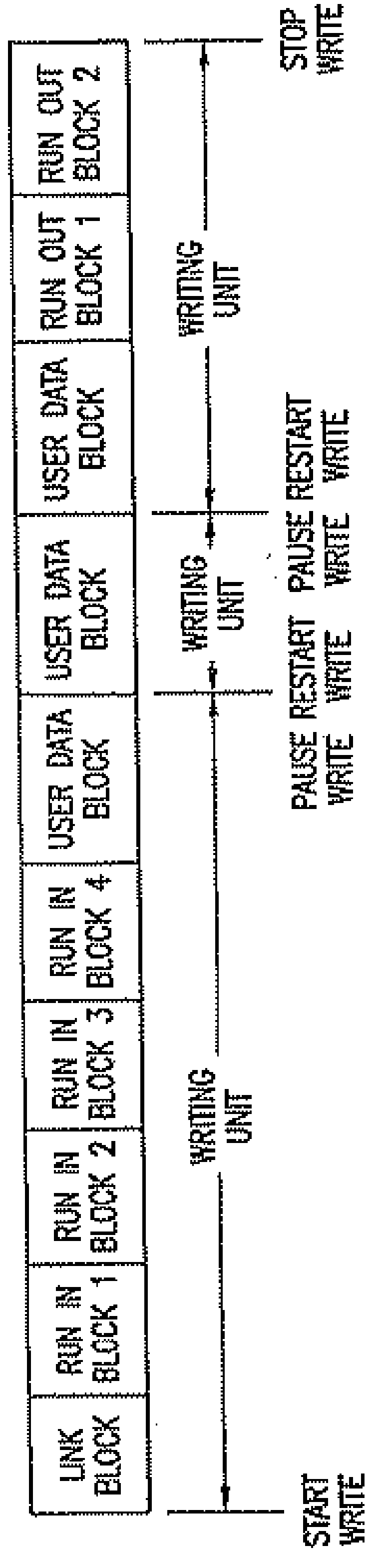
LINK BLOCK
RUN IN BLOCK 1
RUN IN BLOCK 2
RUN IN BLOCK 3
RUN IN BLOCK 4
USER DATA BLOCK
USER DATA BLOCK
USER DATA BLOCK
RUN OUT BLOCK 1
RUN OUT BLOCK 2
WRITING UNIT
WRITING UNIT
WRITING UNIT
START WRITE
PAUSE WRITE
RESTART WRITE
PAUSE WRITE
RESTART WRITE
STOP WRITE

FIG.3

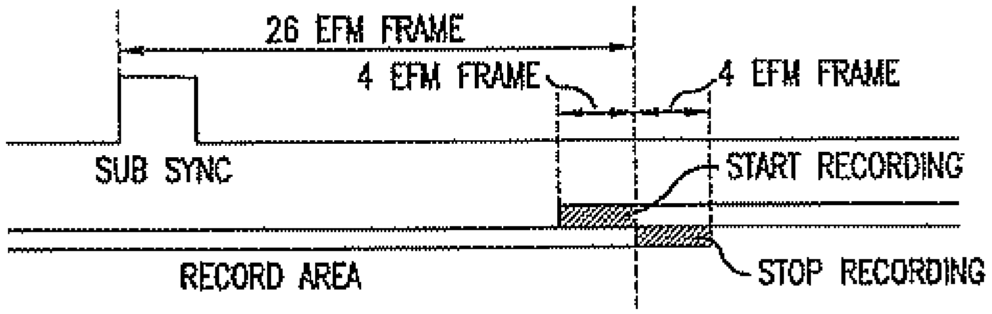
26 EFM FRAME
4 EFM FRAME
4 EFM FRAME
SUB SYNC
START RECORDING
RECORD AREA
STOP RECORDING

FIG.5

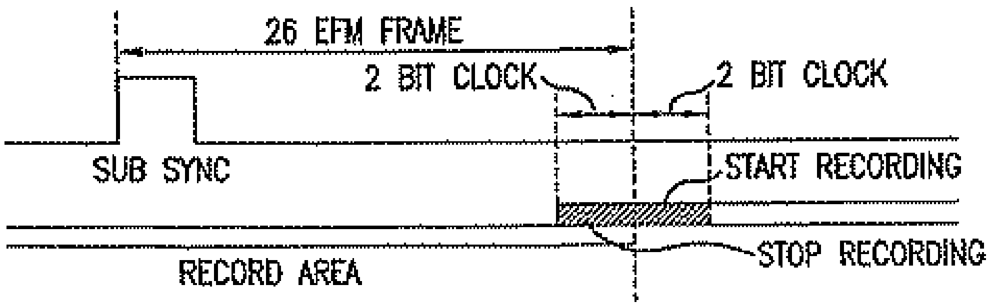
26 EFM FRAME
2 BIT CLOCK
2 BIT CLOCK
SUB SYNC
START RECORDING
RECORD AREA
STOP RECORDING

FIG.6

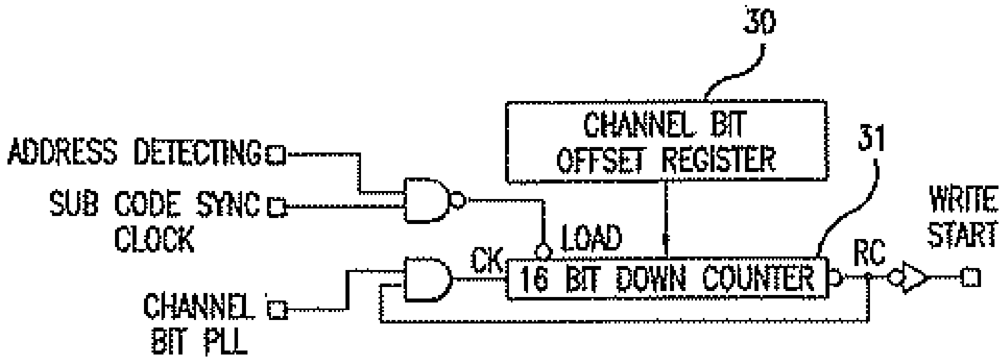
30
CHANNEL BIT OFFSET REGISTER
31
ADDRESS DETECTING
SUB CODE SYNC CLOCK
LOAD
WRITE START
CK
16 BIT DOWN COUNTER
RC
CHANNEL BIT PLL

FIG.7

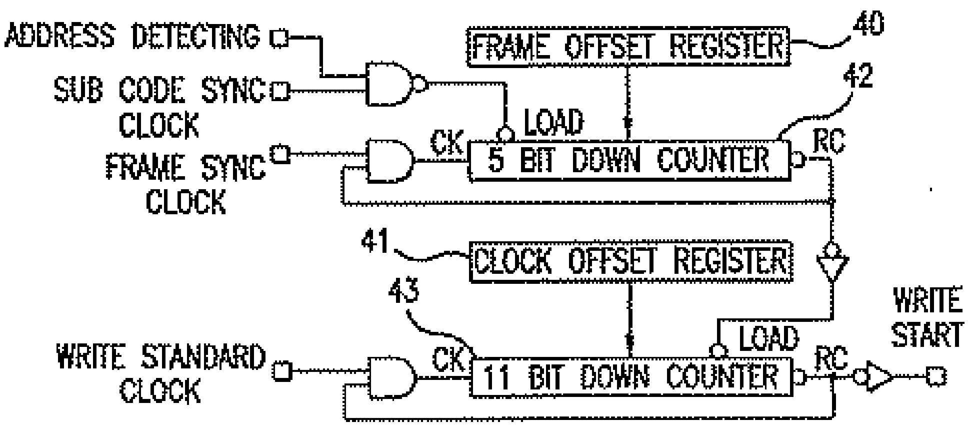
ADDRESS DETECTING
FRAME OFFSET REGISTER
40
42
SUB CODE SYNC CLOCK
LOAD
CK
5 BIT DOWN COUNTER
RC
FRAME SYNC CLOCK
41
CLOCK OFFSET REGISTER
43
WRITE START
LOAD
WRITE STANDARD CLOCK
CK
11 BIT DOWN COUNTER
RC

FIG.9

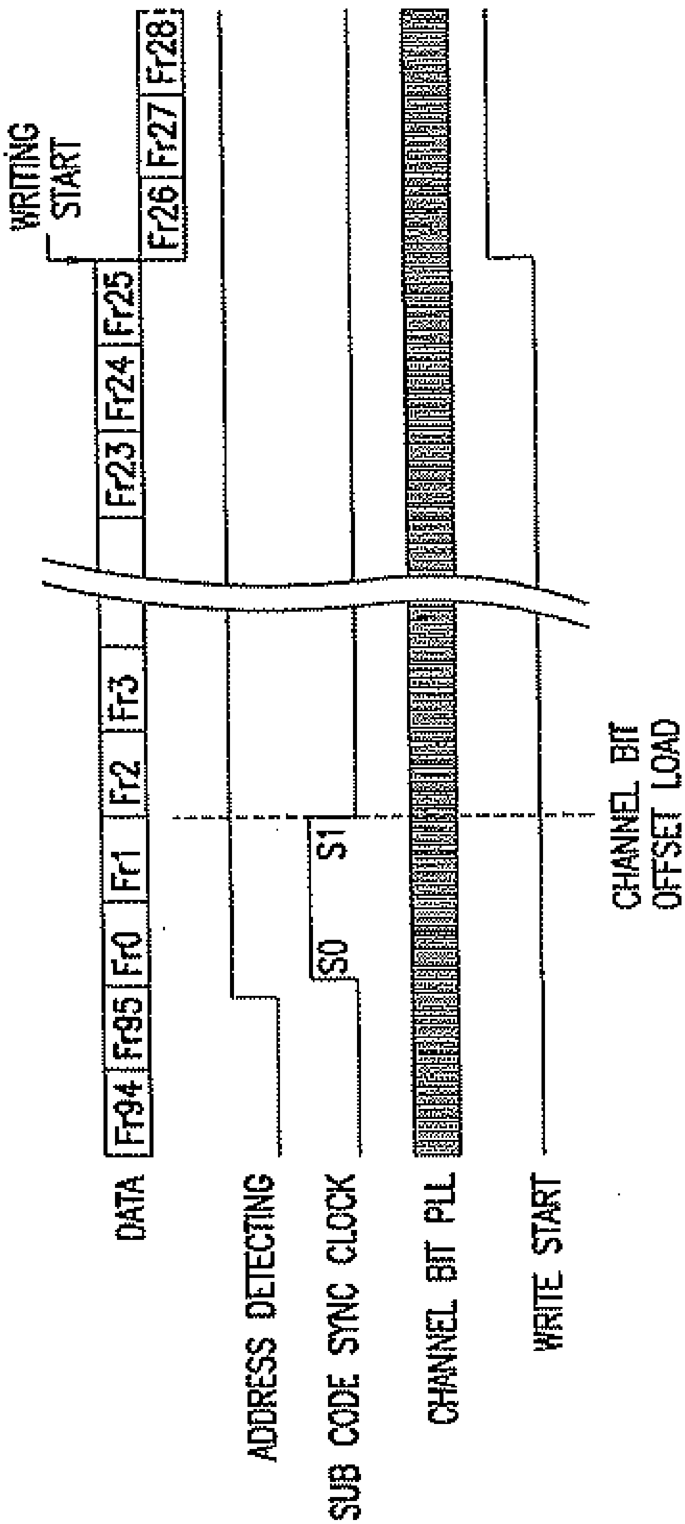
WRITING START
Fr94
Fr95
Fr0
Fr1
Fr2
Fr3
Fr23
Fr24
Fr25
Fr26
Fr27
Fr28
S0
S1
DATA
ADDRESS DETECTING
SUB CODE SYNC CLOCK
CHANNEL BIT PLL
WRITE START
CHANNEL BIT OFFSET LOAD

FIG.8

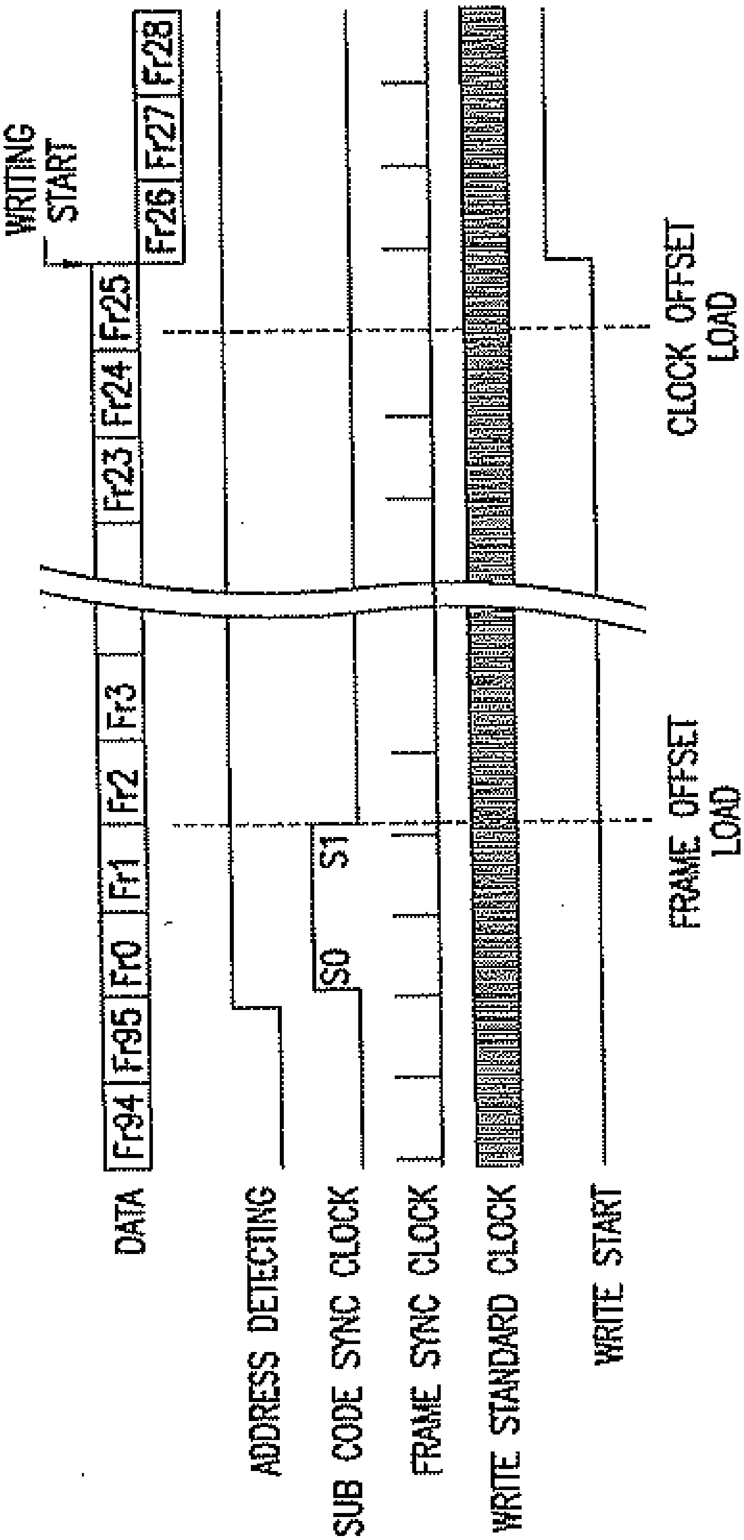
WRITING START
DATA
Fr94
Fr95
Fr0
Fr1
Fr2
Fr3
Fr23
Fr24
Fr25
Fr26
Fr27
Fr28
ADDRESS DETECTING
SUB CODE SYNC CLOCK
S0
S1
FRAME SYNC CLOCK
WRITE STANDARD CLOCK
WRITE START
FRAME OFFSET LOAD
CLOCK OFFSET LOAD

FIG. 10

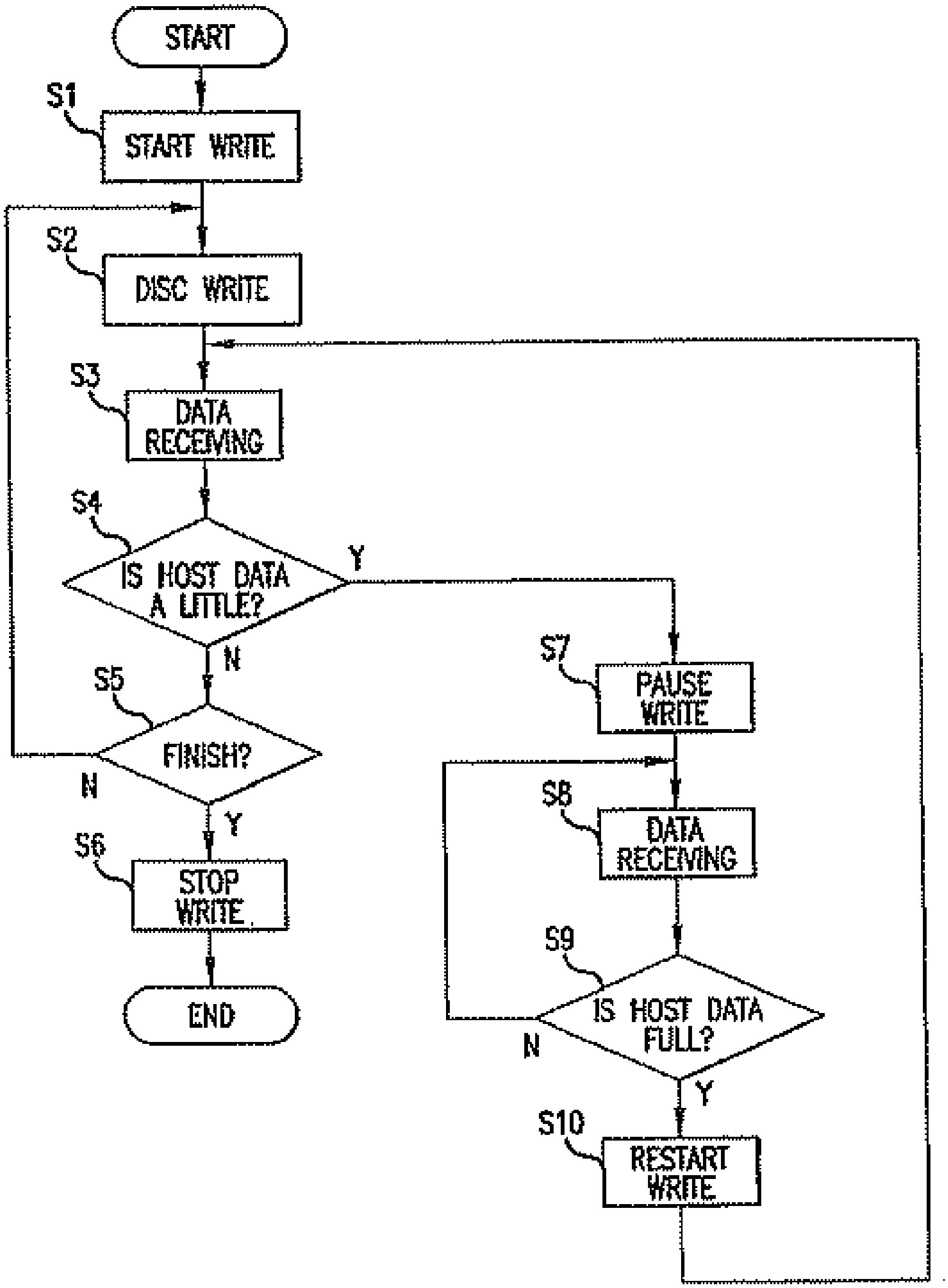
START
S1
START WRITE
S2
DISC WRITE
S3
DATA RECEIVING
S4
IS HOST DATA A LITTLE?
Y
N
S5
FINISH?
N
Y
S6
STOP WRITE
END
S7
PAUSE WRITE
S8
DATA RECEIVING
S9
IS HOST DATA FULL?
N
Y
S10
RESTART WRITE

FIG.11

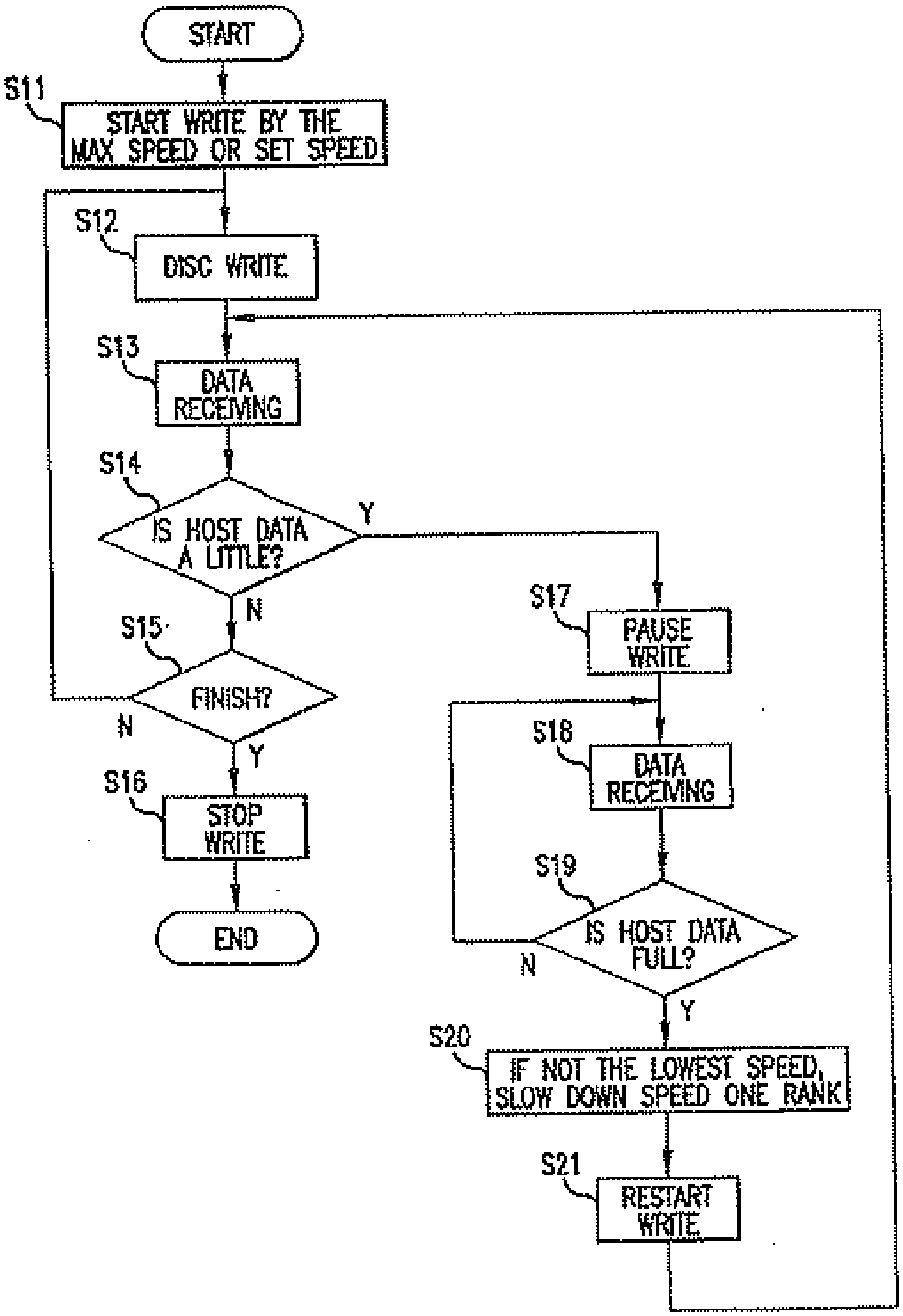
START
S11
START WRITE BY THE MAX SPEED OR SET SPEED
S12
DISC WRITE
S13
DATA RECEIVING
S14
IS HOST DATA A LITTLE?
Y
N
S15
FINISH?
N
Y
S16
STOP WRITE
END
S17
PAUSE WRITE
S18
DATA RECEIVING
S19
IS HOST DATA FULL?
N
Y
S20
IF NOT THE LOWEST SPEED, SLOW DOWN SPEED ONE RANK
S21
RESTART WRITE

FIG.12

OPTICAL DISC APPARATUS

This application is a continuation of application Ser. No. 10/082,345; filed Feb. 26, 2002 which is a continuation of application Ser. No. 09/741,900 filed Dec. 22, 2000 (now U.S. Pat. No. 6,418,099); which is a continuation of application Ser. No. 08/906,290 filed Aug. 5, 1997 (now U.S. Pat. No. 6,198,707). Each of the above listed applications are herein incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical disc drive which records and reproduces information for an optical disc like a CD-R media or a CD-RW media.

2. Description of the Related Art

The recording format of a CD-R or CD-RW optical disc is prescribed in the Orange Book, an industry standard. The Orange Book rules dictate that data sectors which are not consecutively written require lengthy lead-in and lead-out sectors such as Link, Run-In, and Run-Out sectors. These sectors are necessary to enable optical disc drives to synchronize to the data on the optical media. This is because the laser beam must be repositioned each time a new writing session is started, and known optical disc drive positional controls are not sufficiently accurate to position a laser beam at the exact end point of previously written data.

Therefore, conventional optical disc drives need to write data on an entire track, known as Track-at-Once, or an entire disc, known as Disc-at-Once, continuously in order to avoid adding lead-in and lead-out sectors. In other words, known optical disc drives must write the entire disc or track in a single writing session.

Conventional optical disc drives employ Cross-Interleaved Reed-Solomon Code (CIRC) encoding which is performed by a CD encoder chip. The CD encoder chip automatically encodes the data in a buffer which temporarily stores data from a host while waiting for the data to be encoded and written to an optical media. Another reason that conventional optical disc drives must write data in a single session is that the CD encoder chip will continue to generate dummy data even if the buffer containing data from the host becomes empty. Continuity of data, or data succession, is lost by inserting and writing dummy data in a head where data from a preceding sector was recorded.

Because conventional disc drives need to write an entire track or disc in a single session, a problem is encountered if the flow of data from the host computer to the optical disc drive buffer is interrupted. Since CD-R and CD-RW optical discs are write-once media, a write failure results in the loss of expensive media.

The problem of maintaining data from the host in the optical disc drive buffer is severe when the writing speed of the optical disc drive is high. Because the data size of a track or disc is large compared to the optical disc buffer size, if the data transfer rate between the host computer and the optical drive is even slightly slower than the speed at which data is written to the optical disc, or data transfer between the host and the optical disc drive is interrupted for even a short period, the buffer may go empty. This problem is known as Buffer Run.

Because hosts transmit data at varying rates, some optical disc drives include a test mode that performs a dummy write operation, during which no data is actually written to the optical disc, to ensure that the transmission rate of the host

is adequate to prevent buffer run. One problem with this method is that it takes twice as long to write the data to the disc. Also, because hosts sometimes encounter non-repeatable problems, the aforementioned method is not perfectly safe and the risk of losing expensive media due to buffer run errors is not completely eliminated.

Therefore, an optical disc drive that can write data consecutively and normally to an optical media in multiple sessions without the loss of data succession is needed.

Even if logical data succession is ensured as described above, data cannot be normally reproduced without physical correspondence of the succeeding portions of data written in multiple sessions.

Usually, a frame gap of up to +/−2 bits may be present without preventing a conventional optical disc drive from properly reproducing data from an optical disc. However, if a conventional optical disc drive attempts to write multiple sessions of data by selecting a writing start point based on a rotating control by a wobble synchronic signal, a frame gap of scores of bits may result. Therefore, synchronization may be off in that portion and several frames of data may be lost.

Therefore, what is needed is an optical disc drive that is able to correctly detect an end portion of data written in a preceding write session so that an accurate write start point is provided for a succeeding write session.

Further, it is desirable that such an optical disc drive should be able to detect the end portion of data written in a preceding write session at low cost.

SUMMARY OF INVENTION

An object of the present invention is to provide an optical disc apparatus characterized by writing means for maintaining data succession by halting CIRC encoding at the end of a preceding write session and resuming CIRC encoding at the beginning of a succeeding write session.

A second object of the present invention is to provide an optical disc apparatus characterized by a counter circuit for counting the channel bit PLL (phase locked loop) which takes timing from the end of previously written data to select a writing start point for a succeeding write session.

A third object of the present invention is to provide a counter circuit for counting a frame sync signal which takes timing from the end of previously written data to select a writing start point for a succeeding write session.

A fourth object of the present invention is to provide controlling means for controlling the writing of data to an optical disc drive according to the present invention. The controlling means pauses a write operation when data from the host has not been transmitted in time for writing to the optical disc, and restarts the write operation when data from the host computer is again available.

A fifth object of the present invention is to provide an alternate controlling means for controlling the writing of data to an optical disc drive according to the present invention. The alternate controlling means pauses a data write operation when data from the host has not been transmitted in time for writing data to the optical disc, reduces the write speed of the optical disc drive, and then resumes the write operation.

In accordance with the first object, the optical disc drive includes a Pause circuit which masks the clock input to the encoders upon the generation of a Pause signal. This prevents the encoders from further inputting and outputting data. Therefore, even if writing to the optical disc occurs in multiple write sessions, data succession is maintained.

In accordance with the second object, one embodiment of an optical disc drive according to the present invention includes a counting circuit which counts the PLL signal derived from the channel bit. The PLL signal has the smallest error for previously written data. It is possible to calculate the end of the data based on this signal, so that the correct writing start point for succeeding data write sessions may be selected.

Many inexpensive and widely used decoder LSIs which are used in known optical disc drives do not output a channel bit PLL, but rather output a frame sync signal and a sub code sync signal as a sub code output. Therefore, in accordance with the third object, a second embodiment of an optical disc drive according to the present invention includes a counting circuit which counts a frame sync signal and a sub-code sync signal to select a writing start point for a succeeding data write session. Accordingly, it is possible to detect the end of the previously written data at low cost.

In accordance with the fourth object, one embodiment of an optical disc drive includes a processor for detecting when data from a host stored in a data buffer is low, generating a pause signal for pausing a data writing operation, waiting until additional data is received from the host, and removing the pause signal so that the data writing operation may resume.

In accordance with the fifth object, another embodiment of an optical disc drive includes a processor for detecting when data from a host stored in a data buffer is low, generating a pause signal for pausing a data writing operation, decreasing the write speed of the optical disc drive, and removing the pause signal so that the data writing operation may resume.

Because an optical disc drive according to the present invention can write in multiple sessions, a data interruption between the host and the optical disc drive does not result in the loss of the media, thereby reducing the cost of operating the optical disc drive. Accordingly, a large data buffer is not necessary, which also lowers the cost of the optical disc drive. This ability to write in multiple sessions also eliminates the need for a test write operation to test the transmission rate of the host computer, which saves time. It is also unnecessary for a user to be aware of the transmission rate of the host and the write rate of the optical disc drive, which simplifies operation of the optical disc drive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a hardware block diagram showing the structure of an optical disc apparatus in accordance with one embodiment of the present invention.

FIG. 2 is a format diagram showing the format of CD-R or CD-RW data on an optical disc.

FIG. 3 is a timing diagram showing an example of a possible timing sequence of plural write sessions for writing data in the format shown in FIG. 2.

FIG. 4 is a circuit diagram of a write control circuit in the optical disc apparatus of FIG. 1.

FIG. 5 is a format diagram showing the positional relationship of the end data written in a preceding write session and start data written in a succeeding write session by a conventional optical disc apparatus.

FIG. 6 is a format diagram showing the positional relationship of the end data written in a preceding write session and start data written in a succeeding write session by optical disc apparatus according to the present invention.

FIG. 7 is a circuit diagram showing a circuit for generating a write start signal at the end of previously written data, as shown in FIG. 6, according to one embodiment of the present invention.

FIG. 8 is a timing diagram showing the write timing of an optical disc drive using the circuit of FIG. 7.

FIG. 9 is a circuit diagram showing a circuit for generating a write start signal at the end of previously written data, as shown in FIG. 6, according to a second embodiment of the present invention.

FIG. 10 is a timing diagram showing the write timing of an optical disc drive using the circuit of FIG. 9.

FIG. 11 is a flow chart showing one method for writing data to an optical disc using an optical disc drive according to the present invention.

FIG. 12 is a flow chart showing a second method for writing data to an optical disc using an optical disc drive according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described with reference to the accompanying drawings.

FIG. 1 is a hardware block diagram showing the structure of an optical disc apparatus according to one embodiment of the present invention. The optical disc 1 is turned by the spindle motor 2. The spindle motor 2 is controlled so as to keep constant linear velocity by the motor driver 3 and the servo 4. The linear velocity can be changed stepwise. The optical pick-up 5 includes a semi-conductor laser, an optical arrangement, a focus actuator, a photo detector, and a position sensor. The optical pick-up radiates laser rays L on the recording surface of the optical disc 1.

The optical pick-up 5 can be moved in a seeking direction. The focus actuator, track actuator, and seek motor are controlled to locate and focus the laser beam L on a target point of the optical disc 1 by the motor driver 3 and the servo 4 based on signals from the photo detector and position sensor of the optical pick-up 5.

When reproducing data, a reproducing signal obtained from the optical pick-up 5 is amplified and digitized by the read amplifier 6 and input to the CD decoder 7, where de-interleave and error correction are carried out.

When the reproduced data is audio or music data, an analog audio signal is derived by inputting the output data from the CD decoder 7 into the D/A converter 12.

When the reproduced data is ROM data, the de-interleaved and error-corrected data from the CD decoder 7 is input to the CD-ROM decoder 8, and further error correction is carried out. After that, output data from the CD-ROM decoder 8 is stored in the buffer RAM 10 by the buffer manager 9. When a complete sector of data is ready, the data is transferred to the host computer by the ATAPI/SCSI interface 11.

When data is to be written to the optical medium 1, the laser beam must be positioned at the writing start point. The writing start point is searched by the wobble signal pressed beforehand in the form of meandering track. The wobble signal includes absolute time information called ATIP. The ATIP information is derived by the ATIP decoder 13. A synchronizing signal produced by the ATIP decoder 13 is input to the CD encoder 14, and it is possible to write data at an accurate position.

Data that is to be written to the optical disc 1 is received from the host computer through the ATAPI/SCSI interface 11. The data is stored in the buffer RAM 10 by the buffer manager 9.

Data writing begins once data is present in the buffer RAM 10. Error correction codes are added to the data, and CIRC encoding is performed, by the CD-ROM encoder 15 and/or the CD encoder 14. The data is recorded on the target optical disc 1 through the laser control circuit 16 and the optical pick-up device 5.

Known optical disc drives cannot immediately begin reading User Data Blocks on an optical disc drive. In order for an optical disc drive to achieve synchronization and data interleave, lead in and lead out blocks are necessary. FIG. 2 shows a format that provides five lengthy lead in blocks comprising a link block and Run in Blocks 1–4 preceding the User Data Block, and two lengthy lead out blocks comprising Run Out Blocks 1 and 2 after the User Data block.

In order to prevent the aforementioned Buffer Run problem, the optical disc apparatus of the present invention is capable of writing user data in multiple write sessions. FIG. 3 illustrates an example of writing data in the format shown in FIG. 2 in multiple write sessions. The optical disc drive of the present invention receives data from the host computer, and carries out Start Write when the buffer RAM 10 is full of data. Start Write includes writing the lead-in and run-in blocks shown in FIG. 2.

When the optical disc drive starts to write the User Data Block, the data remaining in the buffer RAM 10 is reduced. If the amount of data in the buffer RAM 10 is below a preset level, a Pause signal is generated and the writing stops. The optical disc drive then waits for additional data transmission from the host. When the buffer RAM 10 is again full, Restart Write is carried out by removing the Pause signal and data is written from the position at which the writing was paused. When all data from the host computer is written to the optical disc 1, the Stop Write point is reached.

A conventional optical disc drive cannot write data in the aforementioned manner for two reasons. First, a conventional disc drive does not provide a mechanism for stopping the CD-ROM encoder 15 and CD encoder 14 (FIG. 1) when no data is present in the buffer RAM 10. Thus, when no data is present in the buffer RAM 10, the encoders continue to write data, which changes the data format unit actually written on the optical disc 1 from the logical data format received from the host.

The logical data format unit must conform, as prescribed by the Orange Book, to the physical data format unit on the optical disc. If the encoder could be made to stop when data is not present in the buffer RAM 10, it would be easy to ensure that the physical data format units on the optical disc 1 conform to the logical data format units from the host.

FIG. 4 is a circuit diagram showing a circuit which controls data writing by pausing the encoders when a pause signal, indicating that the buffer RAM 10 is awaiting more data from the host, is received. When a Pause signal is input to the circuit, the clock to the CD-ROM encoder 15 and the CD encoder 14 is masked. Therefore, the CD-ROM encoder 15 and the CD encoder 14 stop encoding and stop outputting Write Data.

The Write Gate signal is also masked by the Pause signal. Therefore, data writing for the optical disc stops also. The encoding data in the RAM 21, 22 is maintained during the Pause. Then, when the Pause signal is canceled, writing on the optical disc resumes with data succession maintained. The pause signal is highly synchronized to the pausing and resuming of the data writing.

The second reason why a conventional optical disc drive cannot write data in the manner described in FIG. 3 is that the writing start point of the laser beam L cannot be controlled with sufficient accuracy using spindle motor controls based on the ATIP of the wobble signal.

FIG. 5 is a format diagram showing the positional relationship of the end data written in a preceding write session and start data written in a succeeding write session by a conventional optical disc apparatus. As shown in FIG. 5, a large data overlapping of 4 EFM (eight to fourteen modulation) frames is possible with a conventional disc drive. Such a large error can occur due to spindle motor controller errors. The starting position of the data writing in a conventional disc drive is selected based on the ATIP of the wobble signal without reference to previously written data. When such a large error occurs, frame synchronization is out and it is impossible to reproduce data properly even for an optical disc such as a CD, which has high error correction capacity.

It is necessary, as shown in FIG. 6, to write succeeding data within a +/−2 bit clock error. Thus, it is impossible to accurately position the laser beam to the correct start location using a conventional optical disc drive with writing control based on the spindle motor control.

In contrast to known optical disc drives, the optical disc drive in accordance with the present invention locates the end of the data previously written. The end position is based on the clock used to synchronize written data. The data writing start position is then based on the end position.

FIG. 7 is a circuit diagram illustrating a circuit for generating a write start signal at the end of previously written data (as shown in FIG. 6) according to one embodiment of the present invention. FIG. 8 is a timing diagram showing the write timing of an optical disc drive using the circuit of FIG. 7.

The circuit shown in FIG. 7 generates a write start signal by counting the channel bit PLL signal. The channel bit PLL clock number from the rising position of the sub code sync clock to the end position of data frame 25 is set in the channel bit offset register 30. This number is decided by sub sync clock producing timing (hardware) of the CD decoder. Therefore, the value of the channel bit offset register 30 cannot increase and decrease dynamically. The CD encoder reads the sub code of each frame and produces the sub code sync clock. However, decode delay is a little different because of variable CD decoder chips. Therefore, a gap between the data and the phase of the sub code sync clock is produced. The channel bit offset register 30 adjusts the gap. The apparatus detects the address of the writing start sector 1 by the ATIP or sub Q code, and loads the channel bit offset register 30 value to the 16 bit down counter 31 on the first sub code sync, which is the sub-code sync of the writing start sector. The down counter 31 then decrements on succeeding clock signals. Finally, when the 16 bit down counter 31 reaches zero, it outputs RC (Reset Counter), which is used as the Write Start signal.

Thus, it is possible to accurately start to write from the end of the data written during the preceding write operation. The write start signal for the succeeding portion of data with the smallest possible gap is formed by using the channel bit PLL, which is the signal with the smallest error.

Many inexpensive and widely used decoder LSIs used in conventional optical disc drives do not output a channel bit PLL signal. Rather, a frame sync signal and a sub code sync signal are output by these decoders. It is also possible to use these signals to accurately begin writing succeeding data at the end of previously written data.

FIG. 9 is a circuit diagram showing a circuit for generating a write start signal based on the frame sync and sub

code sync signals from the decoder 7 of the optical disc drive shown in FIG. 1. FIG. 10 is a timing diagram showing the relationship between the input frame sync and sub code sync signals and output write start signal obtained from the circuit shown in FIG. 9.

The circuit shown in FIG. 9 generates a start write signal by counting the frame sync clock. The frame offset register 40 inputs the frame sync clock number from the sub code sync clock to a Fr25 frame sync clock. The clock offset register 41 inputs the Write standard clock number from the Fr25 frame sync clock to the write start position.

Then, the address of the writing start sector 1 is detected by ATIP or sub code. The frame offset register value is loaded to the 5 bit down counter 42 by the first sync code, which is the sub code sync of the writing start sector. The channel bit offset register value is loaded to the 10 bit down counter 31.

When the 5 bit down counter 42 is decremented by the frame sync clock and becomes zero, it loads the value of the clock offset register 41 to the 11 bit down counter 43. When the 11 bit down counter 43 is decremented by the Writing standard clock and becomes zero, it outputs RC, which is the Write Start signal.

In this manner, it is possible to start to write accurately from the end of previously written data based on a count of the frame sync signal. The frame sync signal can be obtained by an inexpensive and widely used decoder LSI. Therefore, the cost of the optical disc drive can be reduced.

The CPU 17, ROM 18 and RAM 19 (FIG. 1) are used to control write operations for the optical disc drive according to one of two methods. One such method is shown in FIG. 11. When writing is to start, the link block and four run-in blocks are written to the disc at step S1. User data in the buffer is written to the disc at step S2. This is the normal writing sequence which starts from the link and run-in blocks. Additional data is received from the host at step S3. At step S4, the amount of data in the buffer is determined to determine whether a buffer run error may be occurring.

If the data in the buffer from the host is not low in step S4, the buffer is checked to determine whether the data is complete at step S5. If data writing is not complete, the data writing continues at step S2. If the data writing is complete, Stop Write occurs at step S6, and the write operation is complete. Stop Write is normal sequence of writing the Run out blocks.

If the data from the host is low in the step S5, a Pause Write signal is generated to pause the write operation at step S7 while more data is received from the host at step S8, thereby preventing a buffer run condition. The content of the buffer is checked at step S9. If the buffer is not full at step S9, additional data is received at step S8. When the buffer is full, writing resumes at step S10 without writing any link blocks, thereby maintaining data succession. The writing operation continues at step S3.

In this manner, when the data transmission from the host is not in time during write operations to the optical disc, the data writing stops. When the data is fully sent from the host, the write operation resumes.

Accordingly, when the data transmission from the host is momentarily interrupted, or the transmission rate is reduced, it is possible to write data on the optical disc by dividing the write operation into a plurality of write operations. Data writing failures can thus be prevented. The size of the buffer RAM necessary for absorbing data transmission rate variations can therefore be reduced, thereby reducing the cost of the optical disc drive.

A second method for controlling the write operation of an optical disc drive according to the present invention is shown in FIG. 12. In this method, the Start Write operation is carried out at the speed set by the host, or at the maximum speed of the disc drive if no speed is specified by the host, at step S11. Data is written to the optical disc at step S12. Additional data is received from the host at step S13. The amount of data in the buffer is determined at step S14. The buffer may become depleted for the reasons discussed earlier.

If the data in the buffer from the host is not low at step 14, it is determined whether the data has completed at step S15. If the data has not completed, data writing continues at step S12. If the data has completed, Stop Write is carried out at step S16 and the writing operation is complete.

If the data from the host is low at step 14, a Pause Write is generated at step S17 so that writing on the optical disc pauses. Then, additional data from the host is received at step S18. When the buffer is full at step S19, the optical disc drive recording speed is lowered one step at step S20 if the speed is not already at the minimum. The pause signal is removed at step S21, and the write operation continues at step S12 without writing any link blocks and maintaining data succession.

In this manner, when the data transmission rate from the host is less than the data writing rate of the optical disc, the data writing stops, the writing rate of the optical disc is stepped down, and data writing resumes.

Accordingly, the optical disc drive continues writing data after automatically changing the data writing speed in response to the data transmission rate from the host. Therefore, it prevents excessively long data writing operations caused by repeated Pauses. Further, a user does not have to check the data transmission capacity of the host and the writing speed of the optical disc driver. Therefore, the write operation is simple, and it is possible to write the data at the maximum capacity of the host.

The entire disclosure of Japanese Patent Application No. 8-206705, filed Aug. 6, 1996, is expressly incorporated herein by reference.

The above description and drawings are only illustrative of preferred embodiments which can achieve and provide the objects, features and advantages of the present invention. It is not intended that the invention be limited to the embodiments shown and described in detail herein. Modifications coming within the spirit and scope of the following claims are to be considered part of the invention.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A method of recording on an optical disc recording media, said method comprising the steps of:

transferring stored input information to an encoder;

transferring encoded information to a record circuit;

causing an input buffer to contain less than a threshold amount of said input information; and

when said input buffer contains less than the threshold amount of said input information, pausing said transferring of said encoded information, to stop said record circuit at a first point on said optical disk recording media while maintaining said encoded information; and

wherein said record circuit does not write any run-out blocks while paused.

2. A method of recording on an optical disc recording media, said method comprising the steps of:

transferring stored input information to an encoder;

transferring encoded information to a record circuit;

causing an input buffer to contain less than a threshold amount of said input information;

when said input buffer contains less than the threshold amount of said input information, pausing said transferring of said encoded information, to stop said record circuit at a first point on said optical disk recording media while maintaining said encoded information;

causing said input buffer to contain at least a second threshold amount of information; and

resuming said step of transferring said encoded information to said record circuit, to thereby restart said record circuit while maintaining data succession across said first point on said optical disc recording media;

wherein said record circuit does not write any run-in blocks during said resuming.

3. The method of claim 2, wherein said record circuit does not write any run-out blocks during said pausing.

* * * * *

EXHIBIT E

Document Number Case Number
073 06-C-0462-C
United States District Court
Western District of Wisconsin
Theresa M. Owens

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IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF WISCONSIN

RICOH COMPANY, LTD., Plaintiff, v. ASUSTEK COMPUTER INC., ASUS COMPUTER INTERNATIONAL, QUANTA COMPUTER INC., QUANTA STORAGE INC., QUANTA COMPUTER USA, INC., and NU TECHNOLOGY, INC. Defendants.	CIV. ACTION NO. 06-C-0462 DEMAND FOR JURY TRIAL
QUANTA STORAGE INC., Third-Party Plaintiff, v. PHILIPS TAIWAN, LTD., BUSINESS LINE DATA, PHILIPS OPTICAL STORAGE, Third-Party Defendants.	

AMENDED COMPLAINT FOR DAMAGES AND INJUNCTIVE RELIEF FOR PATENT INFRINGEMENT

Plaintiff, Ricoh Company, Ltd. ("Ricoh"), complains of defendants, ASUSTeK Computer Inc. ("ASUS"), ASUS Computer International ("ASUS International"), Quanta Computer Inc.

("Quanta"), Quanta Storage Inc. ("QSI"), Quanta Computer USA, Inc. ("Quanta USA"), and NU Technology, Inc. ("NUI") as follows, and demands a jury trial of all issues.

THE PARTIES

1. The plaintiff, Ricoh, is a Japanese corporation. Ricoh is the owner of record of the patents involved in this action. Ricoh designs, makes, and/or sells, among other things, optical storage products.

2. Defendant ASUS is a Taiwanese corporation which has an office at 150 Li-Te Road, Peitou, Taipei 112, Taiwan, R.O.C. On information and belief, ASUS is a manufacturer and/or seller, among other things, of optical storage devices, and ships or causes them to be shipped to the United States.

3. Defendant ASUS International is a California corporation which has an office at 44370 Nobel Drive, Fremont, CA 94538. On information and belief, ASUS International is a seller, among other things, of optical storage devices, and sells them within the United States. On information and belief, defendant ASUS wholly owns and controls defendant ASUS International and uses it as a conduit for the U.S. sale of products that ASUS manufactures. (Defendants ASUS and ASUS International are referred to hereinafter collectively as the "ASUS defendants.").

4. Defendant Quanta is a Taiwanese corporation which has an office at No. 211 Wen Hwa 2nd Road, Kuei Shen Hsiang, Tao Yuan Shien, Taiwan, R.O.C. Ricoh believes that after reasonable opportunity for further investigation or discovery it will have evidentiary support that Quanta is a manufacturer and distributor, among other things, of computer equipment including optical storage devices, and sells them within the United States.

5. Defendant QSI is a Taiwanese corporation which has an office at No. 188 Wen Hwa 2nd Road, Kuei Shen Hsiang, Tao Yuan Shien, Taiwan, R.O.C. QSI is a manufacturer and/or seller, among other things, of optical storage devices, and ships or causes them to be shipped to the United States. On information and belief, defendant Quanta partially owns and controls defendant QSI, directly or via intermediaries.

6. Defendant Quanta USA is a California corporation which has an office at 45630 Northpore Loop, East Fremont, CA 94538. On information and belief, Quanta USA uses, repairs and/or reconstructs, among other things, optical storage devices, at its factories in California. On information and belief, Quanta wholly owns and controls defendant Quanta USA, directly or via intermediaries. Ricoh believes that after reasonable opportunity for further investigation or discovery it will have evidentiary support that Quanta USA is a manufacturer and distributor, among other things, of computer equipment, including optical storage devices, and sells them within the United States.

8. Defendant NUI is a California corporation which has an office at 4044 Clipper Court, Fremont, CA 94538. On information and belief, NUI is a manufacturer and wholesaler, among other things, of optical storage devices, and sells them within the United States. On information and belief, New Universe Technology, Inc. wholly owns and controls NUI, directly or via intermediaries. On information and belief, defendant Quanta wholly owned and controlled defendant NUI, directly or via intermediaries, at least until March 2005. (Defendants Quanta, QSI, Quanta USA, and NUI are referred to hereinafter collectively as the "Quanta defendants.").

JURISDICTION AND VENUE

9. This is an action for patent infringement arising under the patent laws of the United States, including 35 U.S.C. § 271. This Court has jurisdiction over this action under 28 U.S.C. §§ 1331 and 1338(a).

10. The defendants knowingly and intentionally participated in a stream of commerce between Taiwan, China, and the United States, including a portion of such stream going from Taiwan or China to the Western District of Wisconsin, such stream of commerce including optical storage devices (hereinafter the "accused products") that are accused in this Complaint of infringing Ricoh's patents, as asserted in greater detail hereinafter. Defendants manufactured such devices or caused them to be manufactured and caused them to be shipped to the United States. Defendants imported such devices, or caused them to be imported, into the United States, and then sold and offered them for sale, or caused them to be sold and offered for sale, in the United States, including to customers in the Western District of Wisconsin, to the injury of the plaintiff, in this district, and in violation of the United States patent laws, as described in more detail hereinafter. Defendants did so through intermediaries that such defendants purposefully selected and via a distribution channel that such defendants intentionally established. In establishing this stream of commerce and distribution channel, the defendants acted in concert with distributors whom they selected, including retailers and other resellers of their products, who sold and delivered the accused products in this judicial district.

11. The defendants have obtained financial gain from their trafficking in the accused products. The defendants have sought and obtained a benefit from sales of such products in this district, and have sought and obtained the benefits of the protection of Wisconsin law. The

defendants reasonably anticipated that some of such products would end up in this district and be sold therein.

12. This Court has personal jurisdiction over the defendants. Venue is proper in this district.

COUNT I – FIRST CLAIM FOR RELIEF AGAINST ALL DEFENDANTS
(Infringement of U.S. Patent No. 5,063,552)

13. Ricoh realleges and incorporates by reference the allegations of paragraphs 1-12.

14. On November 5, 1991, the United States Patent and Trademark Office duly and legally issued to Ricoh U.S. Patent No. 5,063,552, titled "Optical disk apparatus with data transfer rate and rotational speed variable by annular zones." Ricoh has owned the patent at all times since then. The patented invention is directed to a system and a method for adjusting operation of an optical disk drive to permit recording and reproduction of information on annular tracks of an optical storage disk in a manner such that the respective linear speeds of recording or reproducing information are substantially constant within respective annular zones of the disc and the rotational speed of the disk varies accordingly.

15. The defendants have appropriated the invention and sell or offer for sale disk drives embodying it, including, without limitation, ASUS DRW-0804P Drives (by the ASUS defendants) and QSI SBW-242 Drives and QSI SDW-082 Drives (by the Quanta defendants). The defendants have been and still are infringing the foregoing patent by doing the following things, among others:

(a) making or causing to be made optical storage devices that embody the patented system and perform the patented method as part of their normal and intended operation, shipping such devices, or causing them to be shipped, to the United

States, and importing such devices, or causing them to be imported, into the United States, in violation of 35 U.S.C. § 271(a);

(b) offering to sell and selling such devices, or causing them to be offered for sale and sold, in the United States, including, without limitation, in this district, in violation of 35 U.S.C. § 271(a);

(c) contributing to infringement of the patent by selling such devices, knowing them to be specially adapted for practicing the patented invention and not a staple article or commodity of commerce suitable for substantial noninfringing use, and knowing of the aforesaid patent, in violation of 35 U.S.C. § 271(c);

(d) actively inducing infringement of the patented system and patented method by knowingly selling such devices, and in advertising and promotional materials knowingly advising and urging customers to use the patented invention, in violation of 35 U.S.C. § 271(b); and

(e) aiding and abetting other persons to infringe and cause infringement of the patent.

16. Such infringement has injured and damaged Ricoh. Unless enjoined by this Court, the defendants will continue their infringement, irreparably injuring Ricoh.

17. Ricoh has demanded of the defendants that they pay it a royalty or else desist from their infringing use of the invention, but the defendants have failed and refused to do either.

COUNT II – SECOND CLAIM FOR RELIEF AGAINST ALL DEFENDANTS
(Infringement of U.S. Patent No. 6,172,955)

18. Ricoh realleges and incorporates by reference the allegations of paragraphs 1-12.

19. On January 9, 2001, the United States Patent and Trademark Office duly and legally issued to Ricoh U.S. Patent No. 6,172,955, titled "Optical disc recording and reproducing

apparatus for performing a formatting process as a background process and a method for formatting an optical disc by a background process." Ricoh has owned the patent at all times since then. The patented invention is directed to a system and a method for adjusting operation of an optical disk drive to format an optical storage disc as a background process while still allowing a user immediate access to recording information on the disc or reproducing information from the disc.

20. The defendants have appropriated the invention and sell disk drives embodying it, including, without limitation, ASUS DRW-0804P Drives (by the ASUS defendants) and QSI SDW-082 Drives (by the Quanta defendants). The defendants have been and still are infringing the foregoing patent by doing the following things, among others:

(a) making or causing to be made optical storage devices that embody the patented system and perform the patented method as part of their normal and intended operation, shipping such devices, or causing them to be shipped, to the United States, and importing such devices, or causing them to be imported, into the United States, in violation of 35 U.S.C. § 271(a);

(b) offering to sell and selling such devices, or causing them to be offered for sale and sold, in the United States, including, without limitation, in this district, in violation of 35 U.S.C. § 271(a);

(c) contributing to infringement of the patent by selling such devices, knowing them to be specially adapted for practicing the patented invention and not a staple article or commodity of commerce suitable for substantial noninfringing use, and knowing of the aforesaid patent, in violation of 35 U.S.C. § 271(c);

(d) actively inducing infringement of the patented system and patented method by knowingly selling such devices, and in advertising and promotional materials knowingly advising and urging customers to use the patented invention, in violation of 35 U.S.C. § 271(b); and

(e) aiding and abetting other persons to infringe and cause infringement of the patent.

21. Such infringement has injured and damaged Ricoh. Unless enjoined by this Court, the defendants will continue their infringement, irreparably injuring Ricoh.

22. Ricoh has demanded of the defendants that they pay it a royalty or else desist from their infringing use of the invention, but the defendants have failed and refused to do either.

COUNT III – THIRD CLAIM FOR RELIEF AGAINST ALL DEFENDANTS
(Infringement of U.S. Patent No. 6,631,109)

23. Ricoh realleges and incorporates by reference the allegations of paragraphs 1-12.

24. On October 7, 2003, the United States Patent and Trademark Office duly and legally issued to Ricoh U.S. Patent No. 6,631,109, titled "Optical recording method and apparatus, and optical storage medium." Ricoh has owned the patent at all times since then. The patented invention is directed to a system and a method for a high-speed write strategy when recording ("writing") information on an optical storage disc, the strategy being to utilize a predetermined combination of laser pulses, durations, and intensity levels such that it produces a desired quality of information recording and reproduction.

25. The defendants have appropriated the invention and sell optical disk drives embodying it, including, without limitation, ASUS DRW-0804P Drives and ASUS CRW-5232 Drives (by the ASUS defendants) and QSI SBW-242 Drives and QSI SDW-082 Drives (by the

Quanta defendants). The defendants have been and still are infringing the foregoing patent by doing the following things, among others:

(a) making or causing to be made optical storage devices that embody the patented system and perform the patented method as part of their normal and intended operation, shipping such devices, or causing them to be shipped, to the United States, and importing such devices, or causing them to be imported, into the United States, in violation of 35 U.S.C. § 271(a);

(b) offering to sell and selling such devices, or causing them to be offered for sale and sold, in the United States, including, without limitation, in this district, in violation of 35 U.S.C. § 271(a);

(c) contributing to infringement of the patent by selling such devices, knowing them to be specially adapted for practicing the patented invention and not a staple article or commodity of commerce suitable for substantial noninfringing use, and knowing of the aforesaid patent, in violation of 35 U.S.C. § 271(c);

(d) actively inducing infringement of the patented system and patented method by knowingly selling such devices, and in advertising and promotional materials knowingly advising and urging customers to use the patented invention, in violation of 35 U.S.C. § 271(b); and

(e) aiding and abetting other persons to infringe and cause infringement of the patent.

26. Such infringement has injured and damaged Ricoh. Unless enjoined by this Court, the defendants will continue their infringement, irreparably injuring Ricoh.

27. Ricoh has demanded of the defendants that they pay it a royalty or else desist from their infringing use of the invention, but the defendants have failed and refused to do either.

COUNT IV – FOURTH CLAIM FOR RELIEF AGAINST ALL DEFENDANTS
(Infringement of U.S. Patent No. 6,661,755)

28. Ricoh realleges and incorporates by reference the allegations of paragraphs 1-12.

29. On December 9, 2003, the United States Patent and Trademark Office duly and legally issued to Ricoh U.S. Patent No. 6,661,755, titled "Optical disc apparatus." Ricoh has owned the patent at all times since then. The patented invention is directed to a method for adjusting operation of an optical disk drive to permit efficient recording on the disk.

30. The defendants have appropriated the invention and sell disk drives embodying it, including, without limitation, ASUS DRW-0804P Drives and ASUS CRW-5232AS Drives (by the ASUS defendants) and QSI SBW-242 Drives and QSI SDW-082 Drives (by the Quanta defendants). The defendants have been and still are infringing the foregoing patent by doing the following things, among others:

(a) making or causing to be made optical storage devices that perform the patented method as part of their normal and intended operation, shipping such devices, or causing them to be shipped, to the United States, and importing such devices, or causing them to be imported, into the United States, in violation of 35 U.S.C. § 271(a);

(b) offering to sell and selling such devices, or causing them to be offered for sale and sold, in the United States, including, without limitation, in this district, in violation of 35 U.S.C. § 271(a);

(c) contributing to infringement of the patent by selling such devices, knowing them to be specially adapted for practicing the patented invention and not a staple article or commodity of commerce suitable for substantial noninfringing use, and knowing of the aforesaid patent, in violation of 35 U.S.C. § 271(c);

(d) actively inducing infringement of the patented method by knowingly selling such devices, and in advertising and promotional materials knowingly advising and urging customers to use the patented invention, in violation of 35 U.S.C. § 271(b); and

(e) aiding and abetting other persons to infringe and cause infringement of the patent.

31. Such infringement has injured and damaged Ricoh. Unless enjoined by this Court, the defendants will continue their infringement, irreparably injuring Ricoh.

32. Ricoh has demanded of the defendants that they pay it a royalty or else desist from their infringing use of the invention, but the defendants have failed and refused to do either.

PRAYER FOR RELIEF

WHEREFORE, Ricoh prays that the Court enter judgment ordering as follows:

(a) adjudicating and declaring that defendants have infringed, actively induced infringement of, and contributorily infringed the foregoing patents;

(b) preliminarily and permanently enjoining the defendants from further infringement of the foregoing patents by unauthorized use of the inventions patented therein, by defendants and their officers, agents, servants, employees, attorneys and all persons in active concert or participation with them;

(c) that defendants account, and pay actual damages (but no less than a reasonable royalty), to Ricoh for defendants' infringement of the foregoing patents;

(d) that defendants pay treble damages to Ricoh as provided by 35 U.S.C. § 284;

(e) that defendants pay Ricoh's costs, expenses and prejudgment interest as provided for by 35 U.S.C. § 284;

(f) adjudicating and declaring that this case is exceptional within the meaning of 35 U.S.C. § 285 and that Ricoh should be awarded its reasonable attorneys fees; and

(g) granting Ricoh such other and further relief as the Court deems just and appropriate.

DEMAND FOR JURY TRIAL

Pursuant to Federal Rule of Civil Procedure 38, Plaintiff demands a jury trial on all issues.

Respectfully submitted,

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Attorneys for Plaintiff Ricoh Co., Ltd.

CERTIFICATE OF SERVICE

I hereby certify that on the 29th day of December, 2006, I served true and correct copies of the Amended Complaint For Damages And Injunctive Relief For Patent Infringement by electronic and first-class mail to:

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EXHIBIT F

Document Number Case Number
180 06-C-0462-C
United States District Court
Western District of Wisconsin
Theresa M. Owens

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IN THE UNITED STATES DISTRICT COURT

FOR THE WESTERN DISTRICT OF WISCONSIN

RICOH COMPANY, LTD.,

Plaintiff,

v.

ASUSTEK COMPUTER, INC., ASUS COMPUTER INTERNATIONAL, QUANTA COMPUTER, INC., QUANTA STORAGE, INC., QUANTA COMPUTER USA, INC., NEW UNIVERSE TECHNOLOGY, INC., and NU TECHNOLOGY, INC.,

Defendants.

OPINION AND ORDER

06-C-0462-C

In this civil action for monetary and injunctive relief, plaintiff Ricoh Company, Ltd. contends that each of the defendants has infringed four of its patents relating to optical disk drives. Two defendants, ASUSTeK Computer, Inc. and ASUS Computer International, have moved for dismissal on the ground that this court lacks the authority to exercise personal jurisdiction over them.

Plaintiff has the burden to show that this court may exercise personal jurisdiction over defendants, but this burden is somewhat reduced in the absence of an evidentiary hearing.

at least until further discovery is conducted. Purdue Research Foundation v. Sanofi-Synthelabo, S.A., 338 F.3d 773, 782 (7th Cir. 2003) (in absence of evidentiary hearing, court accepts all well-pleaded allegations in complaint as true, unless controverted by challenging party's affidavits; any conflicts concerning relevant facts are to be decided in favor of party asserting jurisdiction); Central States, Southeast and Southwest Areas Pension Fund v. Phencorp Reinsurance Co., Inc., 440 F.3d 870, 876-77 (7th Cir. 2006) (when motion is decided on written submissions, question is whether the plaintiff has "established a prima facie case for personal jurisdiction, such that it should [be] allowed to conduct discovery"). Accord Pennington Seed, Inc. v. Produce Exchange No. 299, 457 F.3d 1334, 1344 (Fed. Cir. 2006). Even under this relaxed standard, plaintiff has failed to make the necessary showing that Wisconsin's long arm statute would authorize an exercise of personal jurisdiction over defendants ASUSTeK and ASUS. Accordingly, I will grant the motion to dismiss.

For the sole purpose of deciding this motion, I find the following material facts from the pleadings and the affidavits submitted by the parties.

JURISDICTIONAL FACTS

Defendant ASUSTeK Computer, Inc. manufactures and sells optical storage devices, including CD and DVD drives. It is incorporated in Taiwan and has its principal place of

business there. Defendant ASUS Computer International is a wholly owned subsidiary of defendant ASUSTeK. Its state of incorporation and location of its principal place of business is California. Defendant ASUSTeK ships drives to the United States; defendant ASUS distributes and sells them there. Defendant ASUS is the sole North American sales outlet for defendant ASUSTeK.

Defendant ASUSTeK's website includes "North America" in a list of 33 countries and regions in which it has a presence. All but seven of these locations are in Europe and Asia. According to BusinessWeek Online, defendant ASUSTeK has made $539 million in profits. (The document submitted by plaintiff does not indicate what time period this covers.) In addition to optical drives, defendant ASUSTeK manufactures and sells motherboards, monitors, notebook computers, graphics cards, personal digital assistants and other electronics.

Defendant ASUS is not registered to do business in Wisconsin; it does not have offices, employees or registered agents here. No "princip[al]s or personnel" of defendant ASUS have traveled to this state.

Defendant ASUS has not shipped any products to Wisconsin. It does not do any advertising there. As of the date defendants filed their motion to dismiss, they were not aware of any sales of their products in this state. Since 2002, defendant ASUS has shipped four or five repair units to addresses in Wisconsin.

Defendants maintain a website that can be accessed anywhere in the world, including Wisconsin, but defendants' products cannot be purchased through that site.

In August 2006, counsel for plaintiff purchased a number of optical disk drives from various vendors throughout the country that counsel located by searching the internet. These purchases included: from Space Center Systems, Inc. in Illinois, two ASUS DRW-1608P2S drives; from Ultradrives.com in California, two QSI SDR-083 drives, two QSI TDR-085 drives and one QSI SDW-082 drive; from Newegg.com (location not specified), two NU EDW-082 drives and two ASUS CRW-5232 A4 drives; from PC Direct in Ohio, one QSI SDW-082 drive; from Priority Computer Parts in California, one ASUS CRW 5232A4 drive; from NetCom Direct in California, two QSI SBW-242 drives; from Surplus Computers in California, three QSI SBW-242 drives; from Price Grabber.com in California, two ASUS CRW-5232AS drives; and from Spartan Technologies in Illinois, three ASUS CRW-5232AS drives.

Each of the drives was shipped to counsel for plaintiff's offices in Madison, Wisconsin. It is counsel's "understanding" that the ASUS drives purchased from Space Center Systems were manufactured by defendant ASUSTeK Computer, Inc. On defendants' website, Newegg.com and Space Center Systems are listed as "US Resellers" for defendants' optical drives. Defendant ASUS does not have an agreement with Space Center Systems, Priority Computer Parts, PriceGrabber or Spartan to sell or distribute ASUS products in

Wisconsin. Of these companies, only Spartan is defendant ASUS's customer. Defendant ASUS has shipped products for Spartan to Pennsylvania.

Plaintiff filed this lawsuit on August 24, 2006.

The website for Radio Shack, a consumer electronics store, offers 21 "ASUS products" for sale online. In January 2007, counsel for plaintiff ordered from this website an ASUS 16x/8x DVD R/RW Dual Layer IDE Drive (Model No. DRW-1608P3S), which was shipped to Madison, Wisconsin. Also in January 2007, the website for Milwaukee PC offered 37 "ASUS products" for sale. Counsel for plaintiff contacted the Madison location of Milwaukee PC and requested the ASUS 16x DVD RW. The store did not have the model in stock, but Madison employees obtained the model from another store in Wisconsin, after which counsel for plaintiff purchased it.

CompUSA has twice included ASUS products in advertisements placed in the Wisconsin State Journal, a newspaper published and distributed in Madison, Wisconsin. On January 28, 2007, an advertisement included the ASUS Deluxe AM2 motherboard; on February 4, 2007, both the ASUS Deluxe AM2 and the ASUS Deluxe AMD 939 motherboards were included. On January 26, the Madison location of CompUSA had available for sale the ASUS ATX Socket LGA775 and the ASUS ATX Deluxe/Wireless Edition Socket AM2.

OPINION

Before turning to the substance of the motion to dismiss, I address two preliminary matters. First, there is some dispute among the parties regarding the governing case law. Defendants ASUSTeK and ASUS cite primarily cases of the Court of Appeals for the Seventh Circuit; plaintiff argues that this is inappropriate in a patent case. Plaintiff is correct that Federal Circuit law controls. Silent Drive, Inc. v. Strong Industries, 326 F.3d 1194, 1201 (Fed. Cir. 2003) ("Because the issue of personal jurisdiction in a declaratory action for patent invalidity and non-infringement is intimately related to patent law, personal jurisdiction . . . is governed by the law of this circuit.") However, there are no substantive differences between a personal jurisdiction analysis in a patent case and any other case. Both the Federal and Seventh circuits apply the same general standards for determining personal jurisdiction as set forth by the Supreme Court. Accordingly, I have considered law from jurisdictions outside the Federal Circuit when it was relevant and persuasive.

Second, the parties have treated defendant ASUSTeK and defendant ASUS as the same for the purpose of this motion. In other words, the parties have assumed that if defendant ASUS has (or does not have) sufficient contacts with Wisconsin making an exercise of personal jurisdiction appropriate, this determination applies to defendant ASUSTeK as well. But see Cannon Manufacturing v. Cudahy Packing Co., 267 U.S. 333,

336 (1925) (existence of parent-subsidiary relationship insufficient to support personal jurisdiction over nonresident parent whose subsidiary has sufficient contacts with forum state). As a result, I have analyzed the two defendants together and will refer to them collectively as "defendants" for the remainder of the opinion.

A. General Principles

Step one in a personal jurisdiction analysis is determining whether the forum state would permit a suit against the defendant. Fed. R. Civ. P. 4(k)(1)(A); Breckenridge Pharmacy, Inc. v. Metabolite Laboratories, Inc., 444 F.3d 1356, 1361 (Fed. Cir. 2006); Silent Drive, 326 F.3d at 1201. Step two is determining whether an exercise of jurisdiction comports with the due process clause. Breckenridge Pharmacy, Inc., 444 F.3d at 1361; Silent Drive, 326 F.3d at 1201.

In its brief, plaintiff suggests that step one is unnecessary in this state because Wisconsin extends its jurisdictional reach to the limits of due process. In support, it cites a single case from 1964 (and a district court case citing back to it) discussing a law professor's interpretation of a previous version of Wisconsin's long arm statute. Flambeau Plastics Corp. v. King Bee Manufacturing Co., 24 Wis. 2d 459, 464, 129 N.W.2d 237, 240 (1964). In more recent cases, the Wisconsin Supreme Court has made it clear that "[e]very personal jurisdiction issue requires a two-step inquiry," including evaluations under both

state law and the due process clause. Kopke v. A. Hartrodt S.R.L., 2001 WI 99, ¶8, 245 Wis. 2d 396, 629 N.W.2d 662. See also Bushelman v. Bushelman, 2001 WI App 124, ¶ 7, 246 Wis. 2d 317, 629 N.W.2d 795.

Certainly, the analyses under the long arm statute and the due process clause may inform each other. Kopke, 2001 WI 99, ¶22. But this does not mean that the state law analysis is superfluous. The Wisconsin Supreme Court has noted expressly that the state long arm statute may be harder to satisfy than due process alone. Fields v. Peyer, 75 Wis.2d 644, 651, 250 N.W.2d 311, 315 (1977) (stating that "in all probability" long arm statute requires "additional contact" beyond what due process requires). Accordingly, I begin with Wisconsin's long arm statute, Wis. Stat. § 801.05. Plaintiff identifies two provisions as potential bases for exercising personal jurisdiction: §§ 801.05(4) and 801.05(1)(d). Because plaintiff has the burden to make a prima facie case, I limit consideration to these provisions.

B. Wis. Stat. § 801.05(4): Local Injury

This provision reads:

> Local injury; foreign act. In any action claiming injury to person or property within this state arising out of an act or omission outside this state by the defendant, provided in addition that at the time of the injury, either:
>
> (a) Solicitation or service activities were carried on within this state by or on behalf of the defendant; or

> (b) Products, materials or things processed, serviced or manufactured by the defendant were used or consumed within this state in the ordinary course of trade.

Wis. Stat. § 801.05(4).

The threshold question is whether there was an "injury to person or property within this state arising out of an act or omission outside this state by the defendant." In support of its contention that there was, plaintiff points to a number of purchases of defendants' products by plaintiff's local counsel and cites case law holding that the location of the injury in a patent case is "the place of the infringing sales" rather than the location of the injured party. Beverly Hills Fan Co. v. Royal Sovereign Corp., 21 F.3d 1558, 1571 (Fed. Cir. 1994) (applying Virginia law). (Of course, it is the case law of the Wisconsin Supreme Court rather than the Court of Appeals for the Federal Circuit that controls this court's application of a Wisconsin statute. Akro Corp. v. Luker, 45 F.3d 1541, 1544 (Fed. Cir. 1995) (citing Ohio law to determine reach of that state's long arm statute). However, the parties do not cite any Wisconsin decisions on this issue and I am unaware of any, so I consider Beverly Hills Fan Co. as persuasive authority.)

Assuming that the Wisconsin Supreme Court would adopt the theory set forth in Beverly Hills Fan Co., plaintiff must still overcome several obstacles to succeed on this theory. First, in its amended complaint, plaintiff identifies only three of defendants' products that allegedly infringe its patents: ASUS DRW-0804P, ASUS CRW-5232 and

ASUS CRW-5232AS. Because the injury is caused by the sale of an *infringing* product, only Wisconsin sales of those products could qualify as an injury under Wis. Stat. § 801.05(4). (To be precise, plaintiff alleges that defendants sell infringing drives "including, without limitation" the models listed above. Although pleading standards under Fed. R. Civ. 8 are liberal, a plaintiff must provide notice of its claim so that the other side may prepare a defense. In the context of alleged patent infringement, this means at least that the plaintiff must tell the defendant which products allegedly infringe the plaintiff's patent. Failing to identify the infringing product in a patent case is akin to failing to identify the retaliatory action in a civil rights case. Higgs v. Carver, 286 F.3d 437, 439 (7th Cir. 2002); see also Phonometrics, Inc. v. Hospitality Franchise Systems, Inc., 203 F.3d 790, 794 (Fed. Cir. 2000) (finding allegations of complaint sufficient in part because they "describe the means by which the defendants allegedly infringe" plaintiff's patent). Thus, to the extent plaintiff intends to include other products of defendants in its complaint, it has failed to satisfy the requirements of Rule 8.)

In its materials filed in opposition to defendants' motion, plaintiff does not point to any sales of Model No. ASUS DRW-0804P in Wisconsin or elsewhere. With respect to the other models in the complaint, plaintiff points to purchases from Priority Computer Parts, PriceGrabber.com, Spartan Technologies and Newegg.com. Priority Computer and PriceGrabber.com are located in California; Spartan is in Illinois; plaintiff does not say where

Newegg.com is located. All other cited purchases were related to models not mentioned in plaintiff's complaint. Of the purchases of the allegedly infringing models, all were made online by counsel for plaintiff and shipped to counsel's office in Madison, Wisconsin.

These facts raise several questions. Does an injury occur "within" Wisconsin when an allegedly infringing product is shipped to Wisconsin after an internet purchase from a company not located in the state? Is the sale of an allegedly infringing product an "injury" covered by the statute? Nagel v. Crain Cutter Co., 50 Wis. 2d 638, 184 N.W.2d 876 (1971) (only "tortious" injuries are covered; alleged violation of patent licensing agreement does not constitute "local injury" within meaning of long arm statute). Is there an "injury . . . arising out of an act or omission outside this state by the defendant" when any harm was caused by purchases of the plaintiff's own agents?

The parties address the last question only, so it is the one I shall consider. I agree with defendants that plaintiff's purchases do not provide a basis for exercising jurisdiction under § 801.05(4).

It is undisputed that plaintiff purchased defendants' products for the sole purpose of providing a basis for personal jurisdiction. It does not appear that either the Wisconsin courts or the Court of Appeals for the Federal Circuit (in construing a comparable long arm statute) has considered whether such purchases may qualify as a "local injury." Neither side cites a case addressing this issue squarely. However, common sense requires a conclusion

that such a forced and artificial exercise cannot provide the basis for personal jurisdiction. Economic harm to plaintiff does not out "aris[e] out of" defendants' actions when no sale would have been made but for plaintiff's choice to make a purchase. Alternatively, a strong argument exists that a self-inflicted wound is not an "injury" at all within the meaning of the statute.

Such a conclusion is consistent with the reasoning of the Court of Appeals for the Federal Circuit in Beverly Hills Fan Co., 21 F.3d at 1571, that the sale of an infringing product in a particular state injures the plaintiff in that state because "the patent owner loses business there" and "the sale represents a loss in potential revenue through licensing or other arrangements." It defies logic to say that a patent holder "loses business" when the patent holder itself purchases a competitor's product. This conclusion is also consistent with the requirement under the due process clause that personal jurisdiction comes from purposeful activity of the defendant, not the plaintiff. World-Wide Volkswagen Corp. v. Woodson, 444 U.S. 286 (1980) (plaintiff's "unilateral act" of bringing defendant's product into forum state not sufficient constitutional basis for personal jurisdiction over defendant); NUCOR Corp. v. Aceros Y Maquilas de Occidente, S.A. de C.V., 28 F.3d 572, 580 (7th Cir. 1994) ("the sufficiency of the contacts is measured by the defendant's purposeful acts").

In its response to defendants' motion to dismiss, plaintiff does not adequately explain how an online purchase it made from a retailer in another state may qualify as an injury

arising out of an act of defendants. Plaintiff cites Stevens v. White Motor Corp., 77 Wis. 2d 64, 73, 252 N.W.2d 88, 93 (1977), for the proposition that it does not matter how a product was brought into the state, but the question in that case was not whether the plaintiff had suffered a local injury caused by the defendant. Rather, in that case, a part manufactured by the defendant exploded in Wisconsin. Not surprisingly, there was no discussion in that case about whether the plaintiff had caused the explosion himself for the sole purpose of creating a basis for jurisdiction.

Another holding in Stevens could benefit plaintiff, even though plaintiff does not discuss it. It is that the plaintiff is not required to come forward with evidence of actual sales in the state. Rather, a court may reasonably infer contacts with the state from other evidence in the record. Stevens, 77 Wis. 2d at 74, 252 N.W.2d at 93.

If plaintiff had purchased the accused products at stores in Wisconsin or even through websites that targeted Wisconsin residents, it might be reasonable to infer that other Wisconsin sales were being made as well. Plaintiff did purchase some of defendants' products locally after it filed this lawsuit. Even assuming that plaintiff may rely on post-filing events to establish personal jurisdiction, Central States, Southeast and Southwest Areas Pension Fund v. Phencorp Reinsurance Co., Inc., 440 F.3d 870, 877-78 (7th Cir. 2006) (existence of personal jurisdiction determined at time of filing), the local purchases were not of products that allegedly infringe plaintiff's patents. Similarly, the post-filing local

advertisements cited by plaintiff involved non-infringing products as well. As noted above, plaintiff identifies no cognizable injury it could sustain from the sale of a non-infringing product, so plaintiff cannot rely on potential sales of those products to satisfy Wis. Stat. § 801.05(4).

All of the *accused* products plaintiff purchased came from retailers located outside Wisconsin or from places unknown. Plaintiff does not suggest that any of those retailers have outlets in Wisconsin that carry the accused products. This fact distinguishes plaintiff's case from the federal cases cited by plaintiff in which courts found it appropriate to exercise personal jurisdiction under long arm statutes similar to Wis. Stat. § 801.05(4). In each of those cases, the record established that the accused products were available for sale in retail outlets located within the forum state. Beverly Hills Fan Co., 21 F.3d at 1560 (accused product available at no less than six stores in forum state; defendant did "substantial amount of business" in forum state); Kernius v. International Electronics, Inc., 433 F. Supp. 2d 621, 624 (D. Md. 2006) (accused products sold across state at various large retailers); LG Electronics, Inc. v. Asustek Computers, 126 F. Supp. 2d 414, 419-20 (E.D. Va. 2000) (accused products, motherboards, sold at "several retailers" in forum state). Plaintiff does not cite a single case in which a court found it appropriate to exercise personal jurisdiction solely on the basis of an online purchase from a retailer located outside the forum state, much less an online purchase made by the plaintiff itself.

Even if I assumed that § 801.05(4) would be satisfied by other Wisconsin residents' purchases of accused products from the websites identified by plaintiff, it has adduced no evidence to suggest that other Wisconsin residents have made such purchases. The record reveals only the companies' names and the information that they each had one of the accused products available for sale as of August 2006. Plaintiff provides no information about how much business these companies do in Wisconsin or elsewhere or, more important, how many of the accused products they have sold to Wisconsin residents. None of the four companies – Priority Computer Parts, PriceGrabber.com, Spartan Technologies and Newegg.com – is immediately identifiable as a large, ubiquitous online store like Amazon.com, such that it would be reasonable to infer without specific evidence that there have been past sales to Wisconsin residents. (Plaintiff does say that Radio Shack offers various products of defendants for sale on its website, but plaintiff does not identify any of these products as accused devices.)

Finally, in the "background" section of its brief, plaintiff cites a Business Week chart showing that defendants generated $539 million in profits during an unspecified period of time. Plaintiff argues that a company so large *must* have made sales in Wisconsin. However, this argument is far too speculative to provide a basis for exercising personal jurisdiction. The figure cited by plaintiff represents the global profits for defendants. Plaintiff provides no sales figures for the United States, much less for Wisconsin. In fact, other information

cited by plaintiff suggests that the vast majority of defendants' business is conducted in Asia and Europe, where defendants have the largest presence. The United States is not even listed separately on defendants' website, but instead is lumped in with "North America."

Even more important, plaintiff provides no information regarding defendants' sales of allegedly infringing products. Defendants manufacture and sell models of optical drives other than those alleged to have infringed plaintiff's patents and many other products as well. The information submitted by plaintiff provides no basis from which it could be reasonably inferred that the allegedly infringing products constitute a significant part of defendants' sales globally, in the United States or in Wisconsin.

The only inference that may be drawn from the current record is that the allegedly infringing products would never have found their way into Wisconsin if plaintiff had not brought them here. Further, plaintiff has not requested discovery on this issue, so I need not consider whether plaintiff should have an opportunity to submit additional evidence. In fact, it is very unlikely that discovery would lead to a different result. The record is clear that plaintiff did everything it could short of opening its own ASUS outlet to find accused products in Wisconsin. Plaintiff's failure to find such products despite its best efforts is strong evidence that defendants do not have contacts with Wisconsin that satisfy the requirements of Wis. Stat. § 801.05(4). In any event, plaintiff has not made a prima facie case that they do.

C. Wis. Stat. § 801.05(1)(d): Local Presence

Alternatively, plaintiff relies on Wis. Stat. § 801.05(1)(d), which provides:

> (1) Local presence or status. In any action whether arising within or without this state, against a defendant who when the action is commenced:
>
> . . . .
>
> (d) Is engaged in substantial and not isolated activities within this state, whether such activities are wholly interstate, intrastate, or otherwise.

This provision is similar to the test for general jurisdiction under the due process clause, under which the plaintiff must show that the defendants' contacts are so "continuous and systematic" that it would be fair to sue the defendant in that state on any matter, even those unrelated to its contacts. Helicopteros Nacionales de Colombia, S.A. v. Hall, 466 U.S. 408, 416 (1984). See also Travelers Insurance Co. v. George McArthur and Sons, 25 Wis. 2d 197, 130 N.W.2d 852 (1964) (to qualify under subsection (1)(d), contacts must be "continuous and systematic"). In considering whether the requirements of Wis. Stat. § 801.05(1)(d) are met, courts look at both the quantity and quality of the defendants' contacts. Shepherd Investments International, Ltd. v. Verizon Communications Inc., 373 F. Supp. 2d 853, 863-64 (E.D. Wis. 2005). (In some cases, courts have considered the contacts' "connection with the cause of action," Druschel v. Cloeren, 2006 WI App 190, ¶8, – Wis. 2d –, 723 N.W.2d 430, which seems inconsistent with a test that determines whether an exercise of personal jurisdiction would be appropriate in *any* case against the defendant.

To the extent § 801.05(1)(d) requires a nexus between the contacts and the lawsuit, an exercise of personal jurisdiction would be improper for similar reasons as those discussed under § 801.05(4).)

In the context of cases involving corporations and other business entities, the Court of Appeals for the Seventh Circuit has characterized the test as whether the defendant "has solicited, created, nurtured, or maintained, whether through personal contacts or long-distance communications, a continuing business relationship with anyone in the state." Stauffacher v. Bennett, 969 F.2d 455, 457 (7th Cir.1992). Another court has stated that the question is whether the defendant's contacts within the state are of the same nature and character as that of a local business, meaning, for example that "a corporation must at least supervise the conduct of its business, produce goods or services, or carry out sales activities in a state." Shepherd Investments International, Ltd. v. Verizon Communications, Inc., 373 F. Supp. 2d 853, 863 (E.D. Wis. 2005).

Plaintiff appears to recognize that it cannot satisfy the requirements of §801.05(1)(d). Its 1 1/2-page argument on this issue is half-hearted at best. Initially, I note that it is undisputed that defendants have not maintained many of the contacts courts consider relevant to an analysis under Wis. Stat. § 801.05(1)(d). They have never visited Wisconsin, Druschel, 2006 WI App 190, ¶10, are not registered to do business in the state and have not engaged in their own advertising or otherwise solicited business in the state,

Shepherd Investments, 373 F. Supp. 2d at 863-64. They have "no employees in Wisconsin, no Wisconsin real estate, no Wisconsin bank accounts, no registered agents in Wisconsin, no customers and no sales people in Wisconsin." Morris Material Handling, Inc. v. KCI Konecranes PLC, 334 F. Supp. 2d 1118, 1121 (E.D. Wis. 2004).

Nevertheless, in its brief, plaintiff points to the following contacts as supporting an exercise of jurisdiction:

• CompUSA advertised two of defendants' products in Wisconsin publication on two occasions after plaintiff filed this suit; two other products of defendants were available for sale at one CompUSA store in Wisconsin;

• Milwaukee PC offers 37 products of defendants for sale on its website. One of its Wisconsin locations has sold at least one of defendants' products. (In addition, counsel for plaintiff avers in an affidavit that a Milwaukee PC employee told him over the telephone that it was "an authorized reseller" of defendants' products. However, plaintiff makes no argument why this evidence should be considered despite the fact that it is hearsay, particularly because Milwaukee PC is not included on defendants' list of authorized resellers, a document that *plaintiff* submitted to the court and on which it relies for other purposes.)

I cannot conclude that either the quantity or quality of the contacts cited by plaintiff satisfies Wis. Stat. § 801.05(1)(d). With respect to quality, none of the sales, offers for sale or advertisements are conducted by defendants themselves and plaintiff has adduced no

competent evidence that CompUSA or Milwaukee PC are customers of defendants or otherwise have a "continuing business relationship" with them in Wisconsin. With respect to quantity, a handful of local sales does not qualify as "substantial" activity. These contacts are a far cry from those in the sole case plaintiff cites, K.W. Muth Co., Inc. v. Gentex Corp., No. 06-C-378-C, 2006 WL 2772828, *2 (W.D. Wis. 2006), in which I found that the defendant had "two alliances with Wisconsin companies" and a "network of distributors within the state."

Wis. Stat. §§ 801.05(1)(d) and (4) are the only two provisions in the long arm statute on which plaintiff relies. Because plaintiff has not made a prima facie case that this court may exercise personal jurisdiction under either of them, it is unnecessary to consider whether defendants have sufficient Wisconsin contacts to satisfy the due process clause.

ORDER

The motion to dismiss brought by defendants ASUSTeK Computer Inc. and ASUS

Computer International is GRANTED. The complaint is dismissed as against them.

Entered this 3rd day of April, 2007.

BY THE COURT:

/s/

BARBARA B. CRABB
District Judge